



MANUAL EXTENSION for AUTOGRAPH v.4

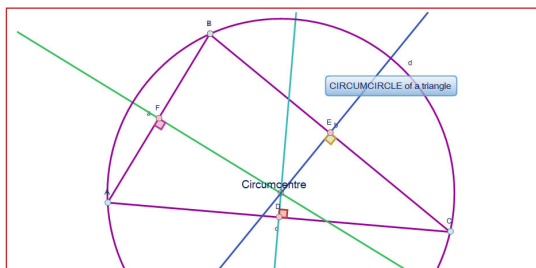
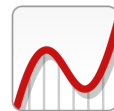
by
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Autograph is designed and programmed by
MARK HATSELL

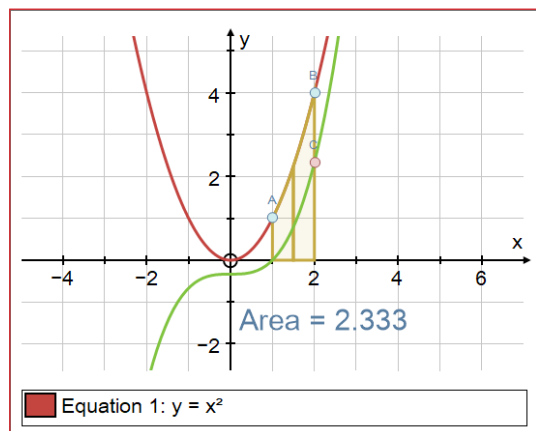
The v.3 Manual is available in the AUTOGRAPH -> HELP Menu

This manual extension will be merged with the
existing v.3 manual in due course

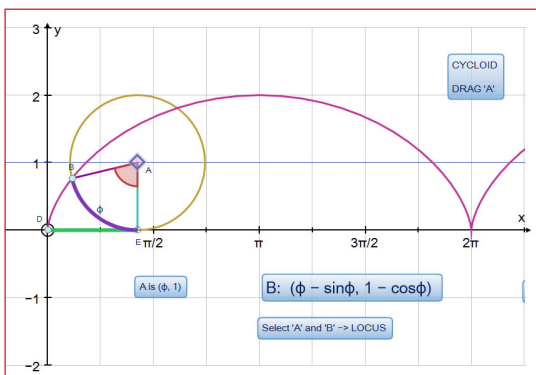
[LINK to v.3 Manual](#)



The Circumscribed Circle



Area function derived from the area attribute



Construction of a cycloid

Introduction

Autograph has had a major make-over, with fresh new icons and design theme. Autograph's celebrated ease of use and powerful "select" and "right-click" user interface has been retained, enabling new and old users to pick up version 4's new features quickly.

Many new mathematical objects have been introduced in both 2D and 3D, and for each object there is an associated list of 'attributes'. The most dramatic features of the new Autograph 4 involve these attributes, which can selectively be used in the new "attribute calculator", or the new "XY" attribute point plot.

Each object also has a label (capital letters for points), which can be hidden, or edited to include a numerical value.

There is also a ground-breaking new "Argand Diagram" page, enabling complex numbers to be explored through dynamic objects. Numbers can be created either as points on the Argand Diagram, or with given coordinates (which can be in Cartesian form or polar form).

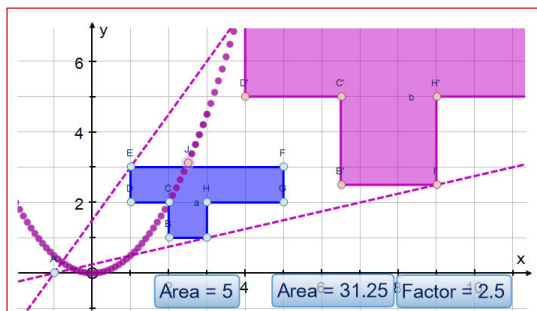
Throughout, there is the option to selectively hide/unhide objects or their labels through a dynamic list of current objects.

Higher Resolution screens are catered for now with appropriate DPI settings, ensuring text size and line thickness are always appropriate.

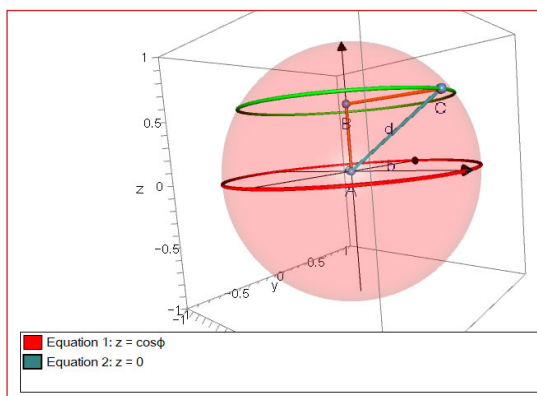
Autograph runs at two levels: Standard Level (no radians, no calculus, etc) and Advanced level.



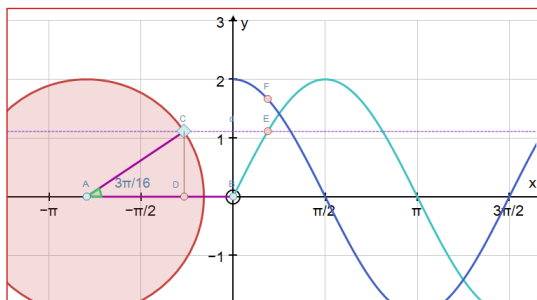
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Illustrating the quadratic nature of area enlargement



Exploring the geometry of a sphere

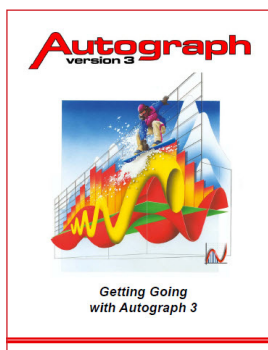
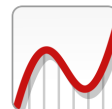


Putting the new "XY Attribute Point" feature to work.

Equation Types

Full details of the many equation types can be found in the v.3 Manual pages 54-57. There is also a useful list of example equations in the v.3 Manual on pages 88-91.

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v.3 topics that still apply to all Autograph pages in v.4:

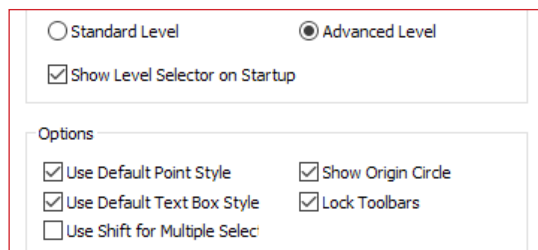
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CHECKING YOUR PREFERENCES

The Preferences dialogue is found in the VIEW menu. It is always good to run through the preferences, to make sure everything is set up the way you want it. Anything changed here is remembered permanently when you exit Autograph.

- General** **Inequalities:** this covers shading of inequalities
Level: change Standard/advanced levels here
Options: The most important is to choose how you like to select more than one object. The default is not to use SHIFT. You can also choose whether to have the circle drawn at the origin
- Plotting** **Options:** use “enhanced plotting” if you can.
Line thickness: eg thicker lines for Classroom use
Vectors: the arrow at the end or mid-way
- 3D Plotting** **Anti-Aliasing Quality:** If you have a superior graphics card you set this to “best”
Rendering: This enables the 3D plotting when there is no access to ‘Direct-X’





AUTOGRAPH'S WAY OF WORKING


The way Autograph works is simple and consistent: create objects on screen, select one or more objects, then use the right-click options to create dependent objects.


Single click on an object to select it, **double-click** to edit it (by opening the dialogue that created it).


THE VIEW MENU includes many of the facilities that make Autograph special:


 **The Constant Controller** - adjusts parameter values with the added feature of controlling the step dynamically, and setting up animations.

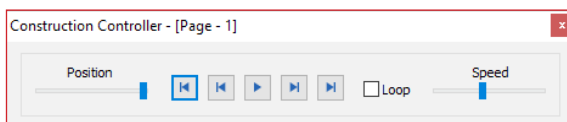
 **The Animation Controller** - any object created by a numerical operation can be animated.

 **The Attribute Calculator** - allows attributes to be included in calculations on-screen

 **Manage Constants** - enables constants to be assigned to and controlled by an attribute.

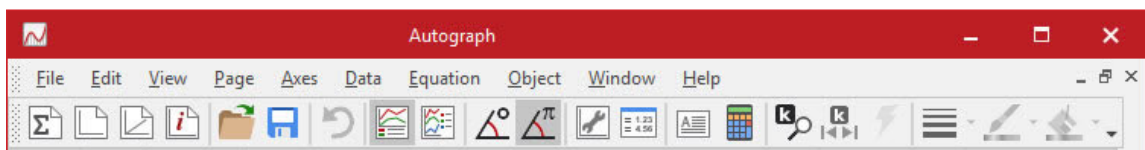
 **On-screen Keyboard** - enables mathematical input throughout Autograph (and independently)

 **The Construction Controller** - a completed construction can be replayed, forward or backwards, automatically (with speed control) or step by step. In the FILE menu there is the option to save the constructions with the file.

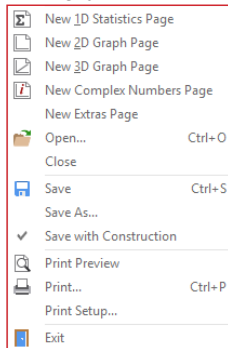




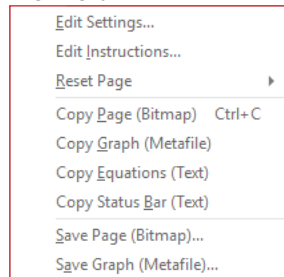
Autograph Menus



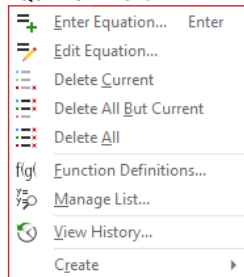
FILE menu



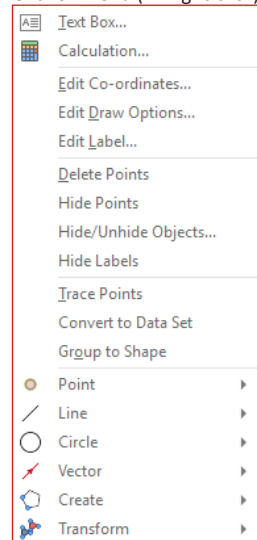
PAGE menu



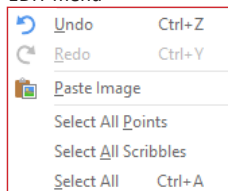
EQUATION menu



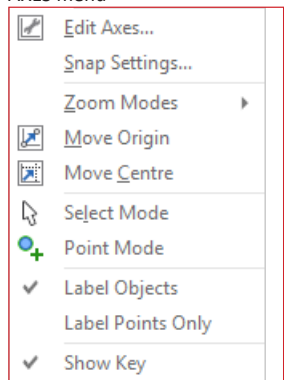
OBJECT menu (=> right-click)



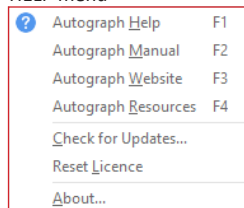
EDIT menu



AXES menu

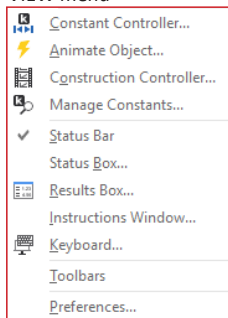


HELP menu



Use "Reset Licence" to change licence information on start-up.

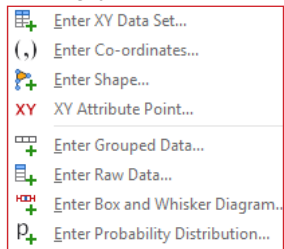
VIEW menu



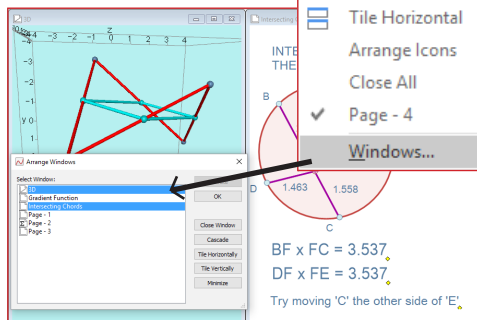
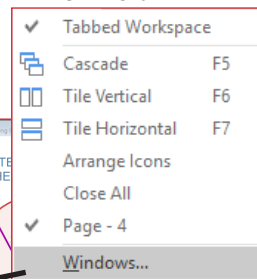
Many menu listings duplicate operations that have icons in the main toolbars.

"Preferences" are discussed on the previous page.

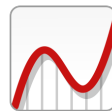
DATA menu



WINDOW menu

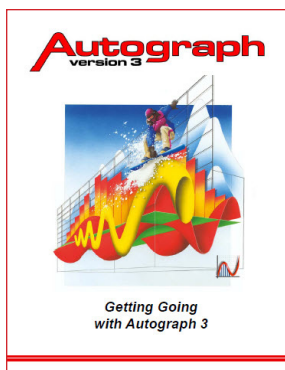
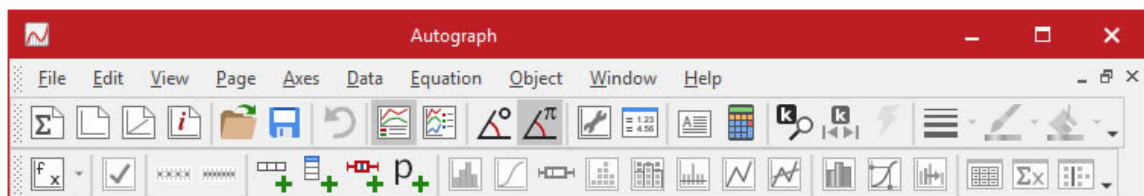


With several pages open, use the "Windows ..." submenu to select two pages (use CTRL) to display as tiled (vertically or horizontally).





1D STATISTICS PAGE



[LINK to v.3 Manual](#)

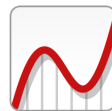
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The much praised single-variable Statistics page in Autograph is largely unaltered, and is well documented in the v.3 Manual, which is accessed in the Autograph HELP Menu.

v.3 topics that still apply to all Autograph Statistics pages in v.4:

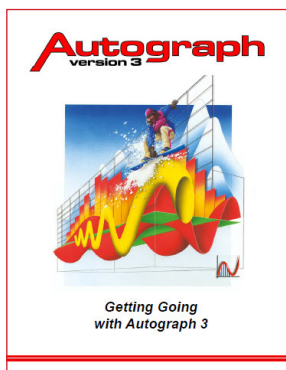
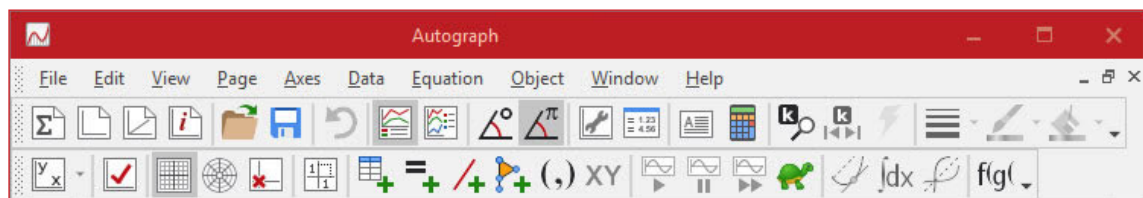
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2D GRAPHING PAGE



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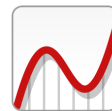
[Return to v.4 Contents](#)

There has been a large amount of development of the 2D Graphing page, with new objects and new facilities. The documentation for v.3 still holds and is summarised here. The v.3 Manual is accessed in the Autograph HELP Menu.

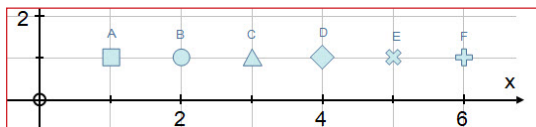
v.3 topics that still apply to all 2D Autograph pages in v.4:

v.3 Manual

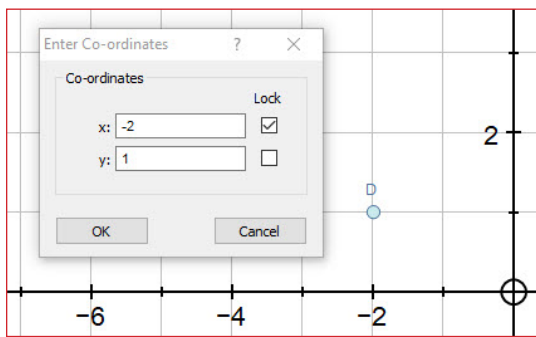
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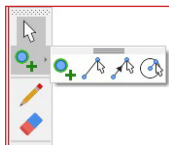
POINTS and LOCI



POINT STYLES: Select one or more points: in "Edit Draw options" there are six styles: square, circle, triangle, diamond, cross, plus. Here you can also set the size and appearance (see v.3 Manual page 18)

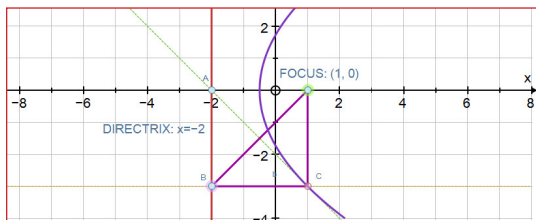


Points can be locked when entered or while being edited



The Point Mode extends to offer free creation of lines, vectors and circles.

The white arrow is the "Select" Mode - where you need to be in order to make further selections.



The locus example shows the construction of a parabola from its property: the locus of points equi-distant from the focus and the directrix. Use "Edit Draw Options" to make selected lines dotted.

Use "Edit Label" to insert "DIRECTRIX" and to display the "value", eg " $x = -2$ ". To create the dynamic locus, select "C" then "B", and use the right-click "Create" -> "Locus".

POINT MODE OPTIONS

There are three types of points you can create while in point mode:

FREE COORDINATE POINTS: click anywhere, but not on an existing object. See the v.3 Manual pages 42-44 for details of how to add objects to one or more selected points, including creating a SHAPE or a DATASET.

ATTACHED POINTS (wait for the black arrow): click on an existing object and the resulting point will be attached.

EVALUATED POINTS (wait for the small circle - no need to hold CTRL):

- at an intersection between a graph and either axis
- at a local maximum or minimum (turning point)
- at an intersection between two graphs/lines (*)

(*) To create a dependent object on an intersection point, eg a tangent, you can double-click on the point to select the association, or select the point and the graph object.

You need to return to SELECT MODE (white arrow) to perform further operations in Autograph. Pressing ESCAPE also achieves this, and a second ESCAPE also clears all current selections. Clicking on any unoccupied space also clears all current selections.

LOCKING POINTS

Entered points can be locked by 'x' or 'y'. Points with constants can only be varied by the constant controller

Points attached to graphs can have the independent variable locked.

POINT MODE EXTENSIONS

Dynamic Line Segments: Create one or more straight line segments between two existing points, or creating two end points.

Dynamic Vectors: Create one or more vectors between two existing points, or creating two end points.

Dynamic Circles: Create one or more circles between two existing points (defining centre and radius), or creating two end points (defining centre and radius)

LOCUS OPTIONS (in "Create" sub-menu)

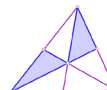
Dynamic Point Locus: Select the point that will replicate first, and also the driving point. The parameters used can be varied dynamically.

Dynamic Line Locus: Select the line that will replicate first, and also the driving point. The parameters used can be varied dynamically

Dynamic Circle Locus: Select the circle that will replicate first, and also the driving point. The parameters used can be varied dynamically.

SHADED AREA OPTION (in "Create" sub-menu)

This enables any selected collection of 3 or more points to be shaded. Similar to a 'group', but the resulting shading cannot be moved. Attributes: area and perimeter.



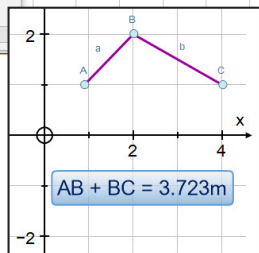


OBJECTS: LABELS and ATTRIBUTES

The dialogue to edit a label. The automatically generated "Name" is a single letter, but this can be replaced by text.

Plotted equations have their equation name set in the Enter Equation dialogue, but you can change it here. The "Value" is the equation as entered in single line.

An example of how the Attribute Calculator can use attributes from existing objects to produce a calculated result, adding in "text before" and "after".



OBJECT LABELS

Objects are points, circles, equations, shapes, data-sets, vectors, etc, and also drawn graphs (from equations).

Points are labelled: **A, B, C, ...**;
other objects: **a, b, c, ...**

In the Axes menu: you can tick to label objects, or to label points only. Applies to subsequent objects created, and also to subsequent pages, until altered.

Right-click options relating to objects and labels:

Hide Label: labels on any number of selected objects can be hidden

Edit label (or double-click on the label): labels can be edited as illustrated. Showing the "Value" is useful.

Hide/Unhide objects: reveals a list of all current objects to allow selective hide/unhide of all current objects.

ATTRIBUTES OF OBJECTS

All objects have attributes, viewed using the Calculator or used to create an XY Attribute point. (See page 13)



ATTRIBUTE CALCULATOR

Calculations can be formed using attributes. With the calculator open, click on any object to reveal a list of attributes. Click on the one you want and it will appear in the calculator. The list includes the attributes of any object that is underneath another object.

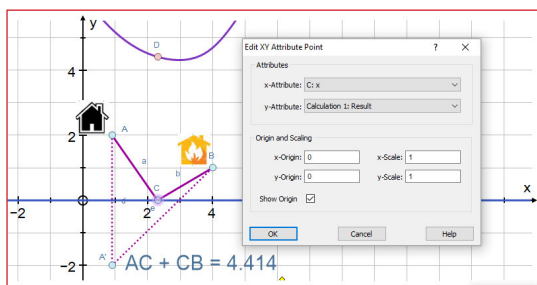
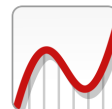
Operation available: +, -, *, /, ABS, SGN, Ceil, Floor, (,)
There are two buttons to enter '√' and 'π'.

Optionally: enter text before and after, or "show working"

You can also use the calculator to display an attribute's value without doing a calculation. You can usefully display the value of any constant (whether already defined or not) by enter its letter, say 'm', and text before "m = ". It will display its current value, or '1' if not yet in use.

The calculator output is itself an object, with its own attribute. This can be 'picked up' for a further calculation, or as an element of a proposed XY Attribute point.

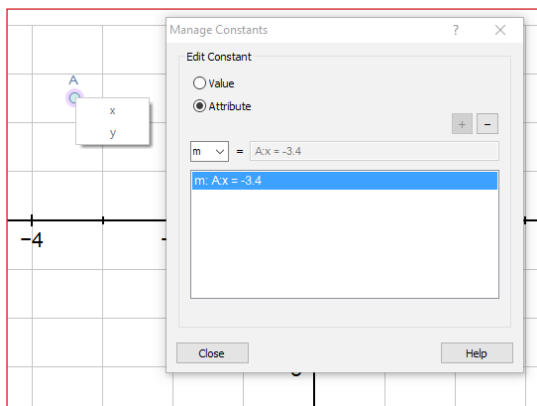
OBJECTS and ATTRIBUTES



Heron's problem (finding the shortest distance from A to B via the river).

The calculator is used to find the distance $AC + CB$. Then the "XY Attribute Point" is used to find the point "D": the x-coordinate is the x-coordinate of the point "C", and the y-coordinate is the result of a calculation ($AC + CB$), resulting in the point D.

You can select "D" then "C" and construct a locus for "D" as "C" moves along the x-axis.



Using the "Manage Constants" feature:

Use the pull-down list to choose which constant you wish to control. Then choose "Value" if you simply want to give a value to your chosen constant.

Choose "Attribute" if you want to associate the constant with an attribute. Click on the object of interest and select the attribute, followed by "+" to add it to the list.

XY XY ATTRIBUTE POINT

Select one or two objects whose attributes you want to use. Right-Click -> Point -> XY Attribute Point

All available attributes are given in a list for each of 'x' and 'y' to choose from.

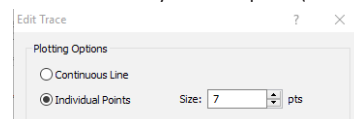
On pressing "OK" a new dependent point is formed. Its position will change if either of the parent attributes change.

Origin and scaling:

In case the new XY point is off the current page, you can position its 'origin' relative to the current origin, and also scale the 'x' and 'y' values.

TRACE:

Add a trace to any selected point (dots or continuous line)



MANAGE CONSTANTS

This facility allows you to assign a constant to an attribute, so that the value of the constant is controlled by the value of the attribute not the by the constant controller.

- choose a constant from the drop-down list
- click on "value" to give your constant a particular value
- click on "Attribute" to associate your constant with a particular attribute. You do this by hovering over an object to reveal its attribute list: select the attribute and press "+".

This facility can be used to set up more than one constant.

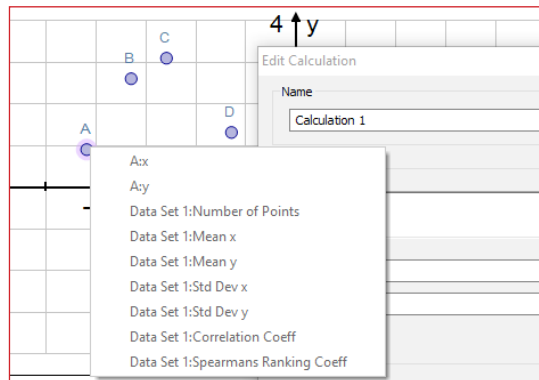
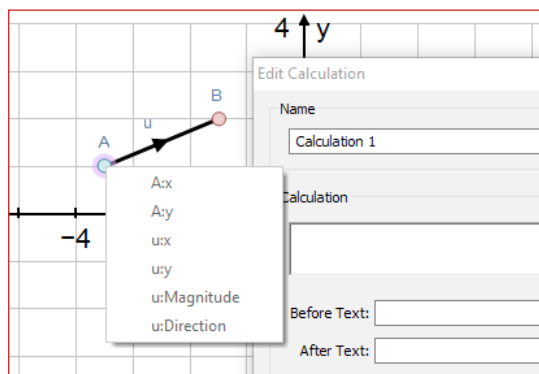
Any constant assigned to an attribute can then be used to define other objects, either directly or in a formula. The behaviour of this new object will be controlled by the attribute.



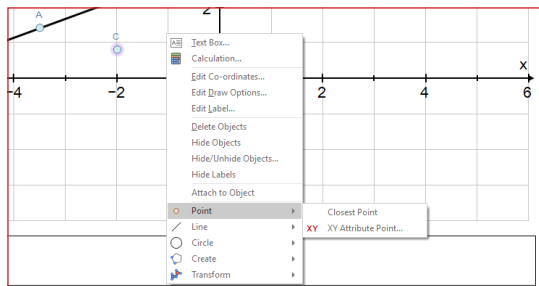
THE RIGHT CLICK MENU relates to the current object selection. If top level objects are required (eg Enter Equation, Shape, Dataset, etc), you need to click in an empty space first, or press ESCAPE, or use the icons in the second toolbar.



OBJECTS and ATTRIBUTES



With the Attribute Calculator open, click on any object to reveal and select the attribute you wish to use.



The right-click menu breaks into up to six sub-menus for the creation of new dependent objects (the 6th is "Vector").

Attributes

	POINTS	x, y (and z in 3D)
	ALL STRAIGHT LINES	Gradient, Intercept
	LINE SEGMENTS	Distance, gradient
	VECTORS: Points at either end: Vector stem:	x, y Cartesian: x, y Magnitude (r) Direction (θ)
	SHAPES Enter a new shape or Group points to shape	Selected point x, y Perimeter, Area
	XY DATASET Enter via spreadsheet or created from selected points Number of points, n	Selected point x, y Mean x, y Std Dev x, y Corr. Coeff Spearman's R. C.
	CIRCLE OBJECTS + other attributes	Centre x, y Radius r Diameter = $2r$
	UNIT GRADIENT TRIANGLE Point on $y = f(x)$ or parametric with $\Delta x = +1$	Gradient
	ANGLE Formed from three points	Angle ($^\circ$ or radians)
	POLYNOMIAL (select 2, 3, 4 points: order 1, 2, 3)	
	POLYNOMIAL (select $n-1$ points, enter gradient at last point) $y = ax^3 + bx^2 + cx + d$	a, b, c, d
	BEST FIT POLYNOMIAL (select n points: up to order 10) $y = a_1x^n + a_2x^{n-1} + a_3x^{n-2} + \dots$	a_1, a_2, a_3, \dots
	CONIC BY ECCENTRICITY (select a line and a point)	
	CONIC (select 5 points) $ax^2 + by^2 + cxy + dx + ey + f = 0$	a, b, c, d, e, f Eccentricity

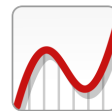
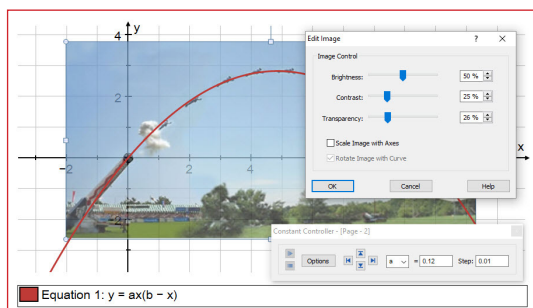
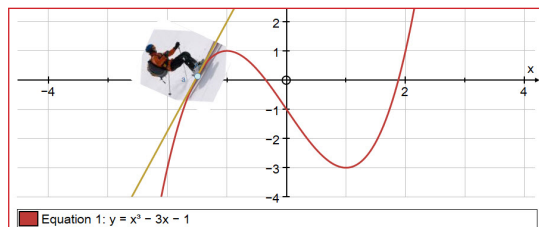


IMAGE options

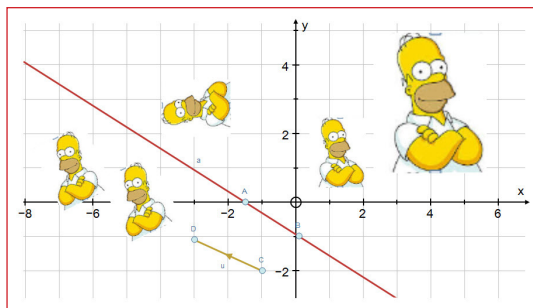


Pasting an image onto an Autograph 2D page, it is useful first to double-click on the image to open "Edit Image". Setting the transparency to 20% usually works well.

If you plan to rearrange the axes at all, untick "Scale Image to Axes" (to avoid distortion), but remember to tick it again before you save the file.



An image can be 'attached' to a point on a curve (taking its direction from the gradient), or to a straight line, line segment or vector (taking its direction parallel to the line)



All the usual transformations can be applied to an image, including that determined by a 2x2 matrix.



IMAGE options

Images can be inserted (from file) or pasted (from clipboard)

Action

Image selected:	Rotate, re-position Nudge with arrow keys Re-scale (drag a corner) Stretch (drag an edge)
Double click to edit:	Control brightness Contrast transparency Scale Image with Axes option
Image and point:	Attach image to a point
Image and vector:	Attach image to vector orientate image to the vector
Image + point on graph:	Attach to point and take gradient of curve at that point
Rotating the image resets the initial orientation Dragging the image resets the initial position	
Image + point + vector	Attach to point taking the direction of vector



TRANSFORMATION OF IMAGES

Action

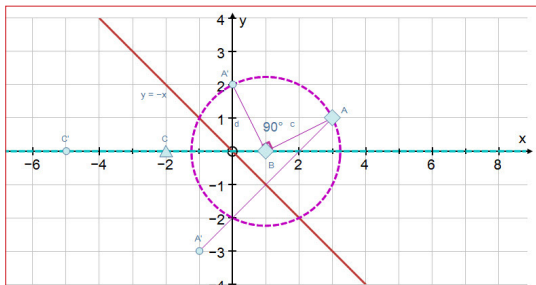
Select an image:	Reflection in x-axis and y-axis Shear along x-axis and y-axis Stretch along x-axis and y-axis Matrix transformation
Select image + a line:	Reflection of the image
Select image + a point:	Enlargement of the image Rotation of the image (counter-clockwise)
Select image + a vector:	Translation of the image



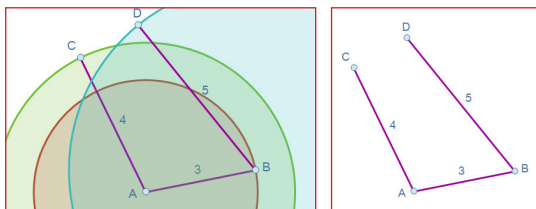
Select any transformed image to animate.



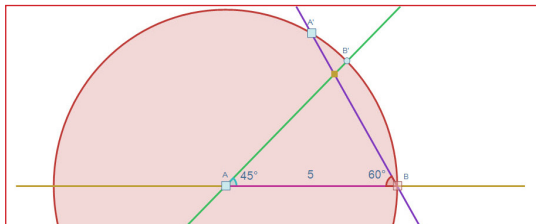
POINTS, LENGTHS and ANGLES



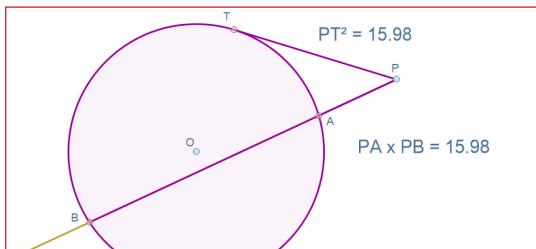
All the standard transformations and animations are available for a single point.



Line segments have been drawn with lengths 3, 4, 5. The unhidden circles can show a 3-4-5 right angle triangle.



A triangle of side 5 + angles 45° and 60°. The line segment AB was drawn later, and its label edited to show the length.



The Tangent-secant theorem: intersection point 'T' found using the point mode. Segments PT, PA and PB drawn, and tangent hidden. Attribute calculator used to show results.



TRANSFORMATION OPTIONS FOR A SINGLE POINT

	Action
1 point + 1 line/segment: (2nd points stays)	Reflection of the first point
1 point then a second point: (2nd points stays) (enter enlargement factor)	Enlargement (*) of the first point
1 point then a second point: (2nd points stays) (enter counter-clockwise angle)	Rotation (*) of the first point



(*) Select the transformed point to animate



TO CREATE A LINE SEGMENT OF A CERTAIN LENGTH

Create a point , A, then a circle, centre A. Enter the radius (a number or a constant), which will be the segment length. Place a point , B, on the circle. Select A and B and draw a Line Segment. Hide the circle.

You can move B in a circular fashion around A
You can move A, and B will follow.



TO CREATE AN ANGLE OF A CERTAIN SIZE

Switch to degrees. Place and select two points 'A' and 'B'. 'B' as the 2nd point will stay. Right-click: Transform -> Rotate. Enter the desired angle (a number or a constant)
A will rotate to A' through the counter-clockwise angle

To show the angle, select A, B and A' in that order
(so that a clockwise motion draws the angle)
Right-click: Create -> Angle. You can move A or B



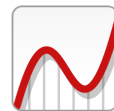
If a constant has been used for the angle, you can animate it with the constant controller.



TO DRAW A TANGENT FROM A POINT TO A CIRCLE

Select a point outside the circle and the circle, right-click: "Line" -> "Tangent". If you want the other one, double-click on the tangent and tick "Tangent 1" or "Tangent 2".

TO DRAW A TANGENT FROM OUTSIDE/ON A POLYNOMIAL
Select the point and polynomial, right-click tangent/normal.

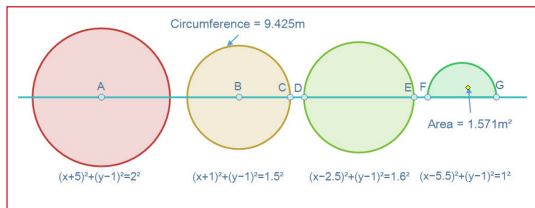


CIRCLE options

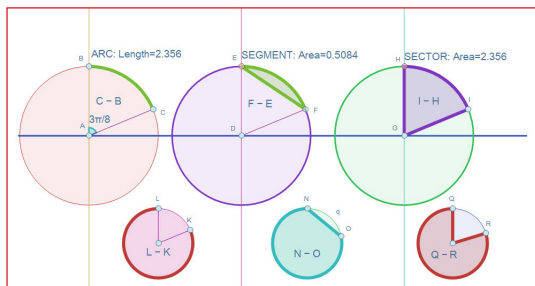
All circle-related objects have these attributes listed:

Centre x, Centre y, Radius r, Diameter = 2r

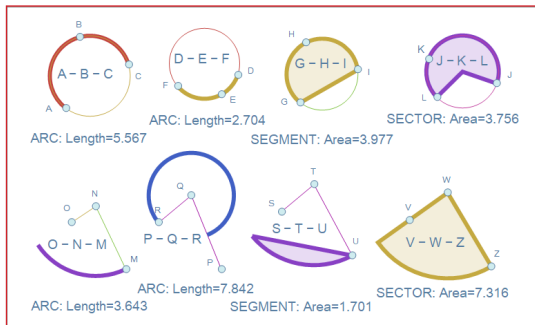
The general principle is to select points in such a way that the object being created proceeds in a **CLOCKWISE** fashion from the last selected point.



For all circle objects the appearance (eg transparency and line thickness) can be adjusted in "Edit Draw Options"



The order of selecting the two points on a circle is indicated: the resulting object is drawn clockwise from the second point. The information is obtained from the "Edit Label" option, including the "Value".



Upper: 3 points determine the circle; order not relevant
Lower: 2nd & 3rd points determine the circle (centre, radius)



CIRCLE OPTIONS in an Autograph 2D graphing page:

One point selected
Additional attributes:
Circle (enter radius)
Circumference = $2\pi r$
Area = πr^2

Centre and point
Additional attributes:
Circle (centre selected first)
Circumference = $2\pi r$
Area = πr^2

2 points selected
Additional attributes:
Circle (diameter)
Circumference = $2\pi r$
Area = πr^2



2 points selected
Additional attributes:
Semicircle
Perimeter = $\pi r + 2r$
Area = $\frac{1}{2}\pi r^2$



2 points on a circle
Additional attributes:
Arc (clockwise from second pt)
Angle (in deg or rad)
Arc length = $r\theta$



2 points on a circle
Additional attributes:
Segment (clockwise from 2nd)
Angle (in deg or rad)
Perimeter = $r\theta + 2r\sin(\frac{1}{2}\theta)$
Area = $\frac{1}{2}r^2\theta - \frac{1}{2}r^2\sin\theta$



2 points on a circle
Additional attributes:
Sector (clockwise from 2nd)
Angle (in deg or rad)
Perimeter = $r\theta + 2r$
Area = $\frac{1}{2}r^2\theta$

3 points selected
Additional attributes:
Circle
Circumference = $2\pi r$
Area = πr^2

3 points selected
Centre of circle

3 points selected
Arc
Segment
Sector

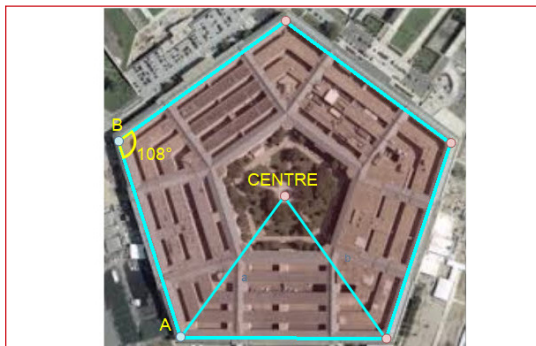
3 pts determine the circle, 1st and 3rd pts the arc limits

3 points selected
Arc (with centre)
Segment (with Centre)
Sector (with centre)

2nd pt is the centre, the 3rd determines the radius

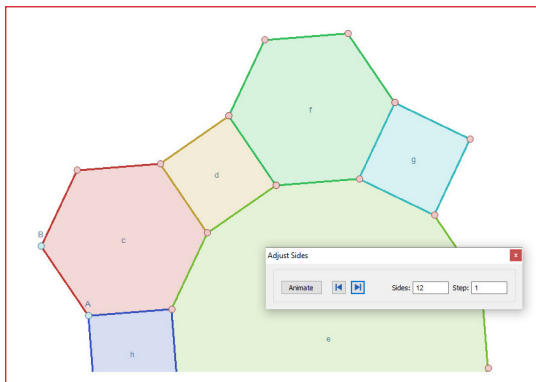


REGULAR POLYGONS



With an aerial photo of the Pentagon building in Washington pasted onto an Autograph page (with axes turned off and equal aspect on):

- Axes menu -> Snap Settings Choose "Custom" set to 0.01
- Place a point at two vertices, A and B.
- Select A then B and go to Create -> Regular Polygon (2pts)
- Choose to show the centre point.
- To show the interior angle at B, switch to degrees, and select A then B then the next vertex, -> Create -> Angle
- To change font size and colour to yellow, use the "Edit Label Display Options" in the Edit Label dialogue
- To change the appearance of the pentagon, select it and use "Edit Draw Options"
- To draw the two radii, use the point mode line segment extension.



In this example, create a hexagon based on two points A and B, then a square on two other vertices, then on two more vertices make another polygon: select it and use "Animate" to increase the number of sides to 12.



REGULAR POLYGON OPTIONS

Polygon attributes:

Number of sides, n
Side length, d
Perimeter = nd
Outside radius, r
Inside radius, $s = \sqrt{r^2 - d^2/4}$
Area $A = \frac{1}{2}nds$
Interior angle = $(n-2) \times 180^\circ/n$
Centre x , Centre y

(in degrees)



A REGULAR POLYGON: TWO POINTS AS THE FIRST SIDE

Select 2 points. The rule is that the polygon will drawn in a CLOCKWISE manner from the second point.

Right-click: Create -> Regular Polygon.
Enter number of sides ≥ 3
Option to show the centre

$n = 3$:	Equilateral Triangle
$n = 4$:	Square
$n = 5$:	Regular Pentagon
$n = 6$:	Regular Hexagon



A REGULAR POLYGON: FIRST POINT IS THE CENTRE

Select 2 points: the first is the centre.
Same rule: the polygon is drawn in a CLOCKWISE manner from the second point.

Right-click: Create -> Regular Polygon.
Enter number of sides ≥ 3

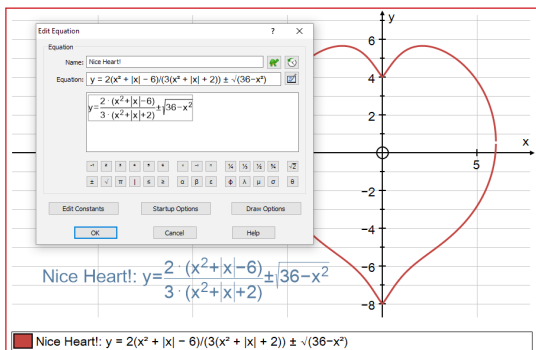
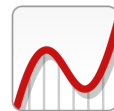
New polygons can be created on any two points, including vertices of an existing polygon.



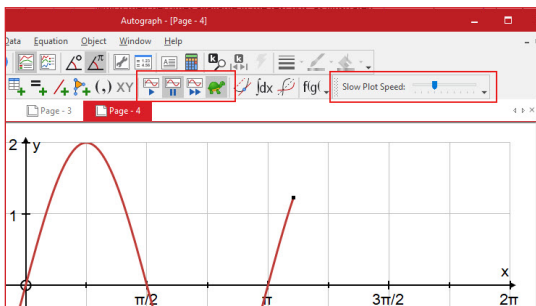
With a polygon selected, the number of sides can be animated

1 point (P) and a circle: **Inversion** [$OP \times OP' = r^2$]
P constrained, eg on a straight line:
select P and P': Locus (eg a circle)

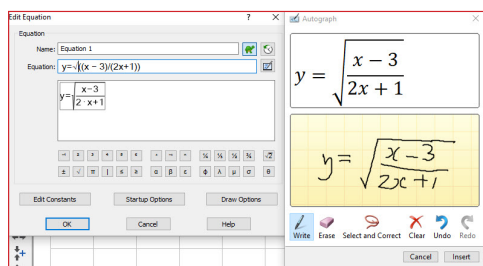
GRAPHING 2D FUNCTIONS



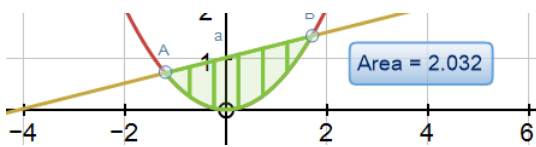
A 2D Equation is entered using standard 'one-line' entry, using mathematical notation from the buttons.



Slow Plot can be controller dynamically by a slider.



Hand-written entry can be useful



Area between 2 graphs: select A, B, top graph, bottom graph

ENTER/EDIT EQUATION

The equation is entered in one-line form, using any of the symbol buttons below.

Your entry is interpreted in 'true-notation' mathematics, which then becomes available in the text box, as illustrated.

Ceiling and Floor functions covered as "ceil(x)" and "floor(x)".

Equation Types

Full details of the many equation types can be found in the v.3 Manual pages 54-57. There is also a useful list of example equations in the v.3 Manual on pages 88-91

Start-up domain settings

can make use of constants that are in use elsewhere

Slow Plot

The button here duplicates the button on the 2D toolbar. Pale blue background means "ON"

During a slow plot, the speed can be adjusted in real-time using the slider, otherwise use the standard buttons:



Re-plot (and re-visit the "start-up Options")

Pause/continue (or pressing spacebar does this)

Fast Forward (to the end)



History

This button reveals a list of previous equation entries



Hand-written equation entry

This allows entry by hand. Obviously write carefully.

Erase: you can wipe out individual characters

Select and Correct: lasso any single character you have written and select from the list of possible interpretations to put mistakes right (hopefully!)

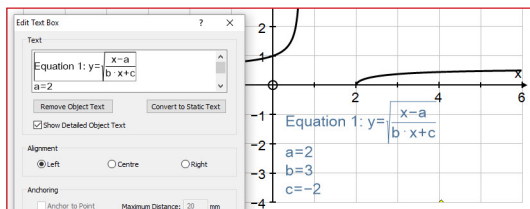
Insert: this will fill in the one-line expression as well as the 'true mathematics' notation. Once you have done this, any subsequent re-editing will need to be done on the one-line entry, as you cannot return to the hand-writing mode.



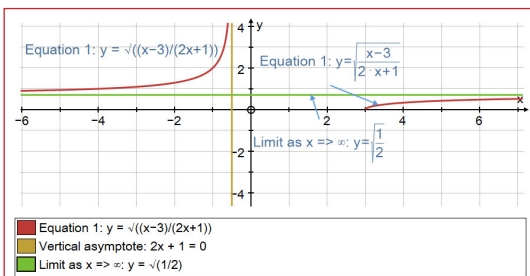
The area between two functions: select the two intersection points, or ANY two points, in the order lower limit, higher limit, then the top function then the bottom function. If the points are not on a graph they can be moved around.



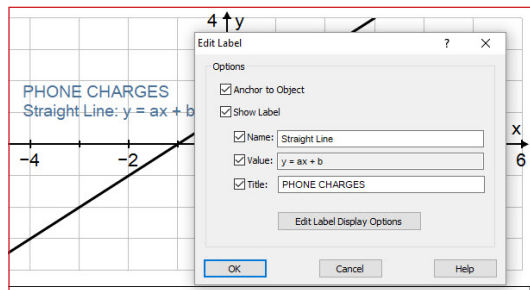
GRAPHING: TEXT BOX and LABEL options



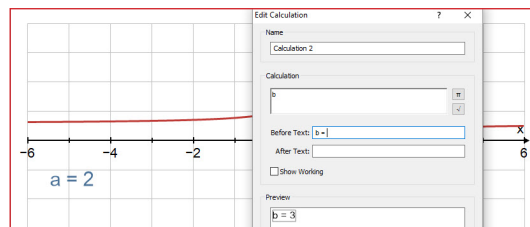
A dependent text box with true mathematics interpretation of the equation, together with a list of any constants in use.



Top left: a text box with text copied from the Status Bar,
Top Right: a Text Box formed with Equation 1 selected.



You can edit the label for a plotted graph, including its
"value" (equation as entered in 'one-line' form)

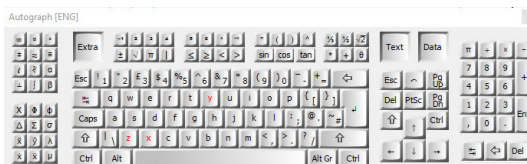


You can use the Attribute Calculator to place individual values
of any constant.

TEXT BOX

FREE TEXT BOX

There are two types of text box. A free text box is one that is created with no object selected. The Text Box accepts straight text, including of course any symbols you may wish to add from the **onscreen keyboard** (in the VIEW menu):



DEPENDENT TEXT BOX

With a single object selected, the text box displays information about that object using "MathML", so that the mathematical information is displayed in true notation. You may want to check the type size in "Edit Font".

If the graph object includes constants, these are also listed with their current values (these update in real time if the constants are subsequently varied)

USING A GRAPH OBJECT'S LABEL

If you select a graph and visit the right-click option "Edit Label", you can

- Show/hide Label
- Show its "Name" (eg "Equation 1", but this is editable)
- Show its "Value" (its equation as entered in 'one-line')
- Show an optional title

You may find it useful to edit the type size in "Edit Label display Options"

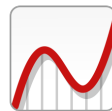
USING THE STATUS BAR INFORMATION IN A FREE TEXT BOX

If you prefer your information in a 'Free' text box in straight text, another method is:

- Select the graph and note the information in the Status Bar (at the bottom of the Autograph page)
- Page -> Copy Status Bar (Text) or Copy Equations (Text)
- Deselect the graph, open a new Text Box and paste.

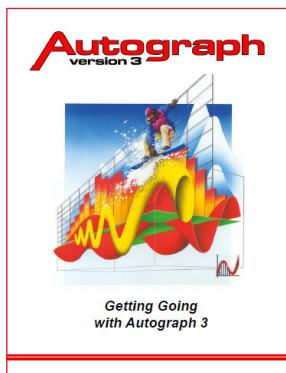
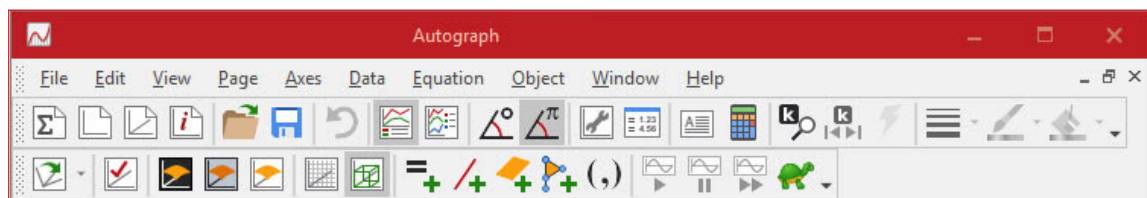
ZOOMING

Zooms are dynamic, any existing text box or label will adjust to be visible in the new setting.



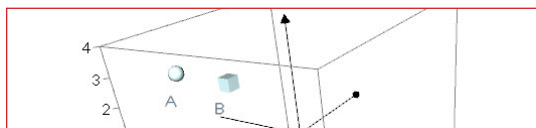


3D GRAPHING PAGE



[LINK to v.3 Manual](#)

[Return to v.4 Contents](#)



POINT STYLES : Select one or more points - in "Edit Draw options" you can choose the point style: Sphere or Cube.

RIGHT-CLICK SUB-MENUS

The right-click menu places common dependent objects in seven sub-menus: Point, Line, Plane, Circle, Vector, Create, Transform

SCENE CONTROL

CTRL-drag: moves the "camera" in and out
SHIFT-drag: moves the scene about

AUTO-SCENE SPIN

Give the scene a gentle swipe one way or the other to set off a gradual rotation of the scene. Click anywhere to stop.

There has been a large amount of development of the 3D Graphing page, with new objects and new facilities. The documentation for v.3 still holds and is summarised here. The v.3 Manual is accessed in the Autograph HELP Menu.

v.3 topics that still apply to all 3D Autograph pages in v.4:

v.3 Manual

Standard and Advanced Levels	p.66
Edit Axes in 3D; drag and zoom	p.68
Adding points in 3D	p.68
Straight lines and planes in 3D	p.69
Vectors in 3D	p.70
Calculated points and angles	p.71
3D Shapes and Transformations	p.72
Entering Explicit and Implicit Equations	p.73
Volumes of Revolution	p.74
3D Parametric and Polar Equations	p.75

3D OBJECT LABELS (same as 2D)

Points: A, B, C, ...; other objects: a, b, c, ...;

Options in Axes menu:

- Label objects
- Label points only

Right click options:

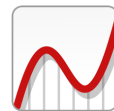
Hide/show labels on selected objects
Edit Label

3D TEXT BOX

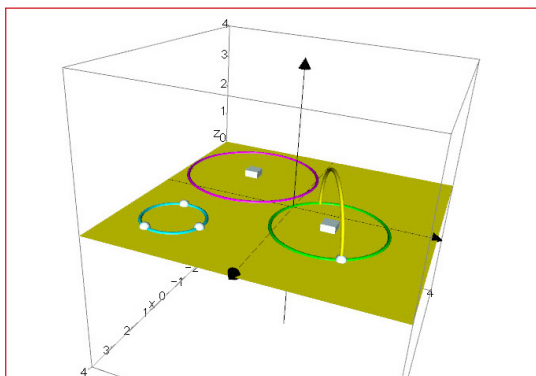
either Free or Dependent (same as 2D) - on a 3D page the box always orientates to face the front.

3D ATTRIBUTES, CONSTANTS and CALCULATIONS

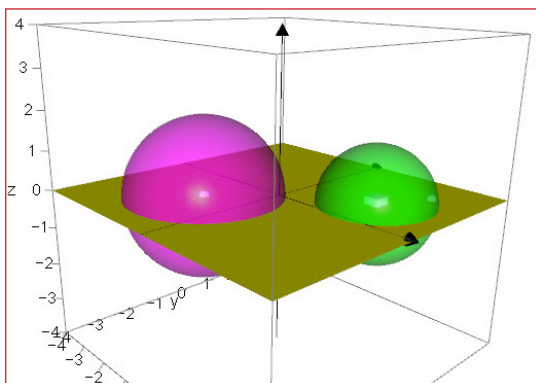
these operate the same as on a 2D page.



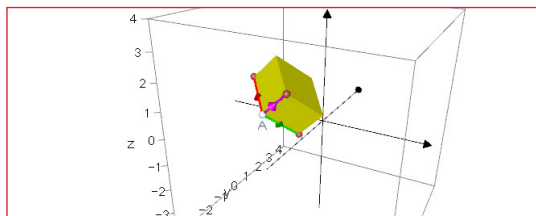
3D: CIRCLES AND SPHERES



Various circles that can be constructed in 3D, based on an existing plane



A sphere based on either a single point (enter the radius) or a pair of points. Spheres are transparent, and the centre can be picked up by the mouse.



A parallelepiped can be defined by three vectors and a point. Its volume is calculated and available as its attribute.



CIRCLE options

All circle-related objects have these attributes listed:

- Centre x , centre y , centre z
- Radius, r
- Diameter $= 2r$
- Circumference $= 2\pi r$
- Area $= \pi r^2$

Select: one point on a plane:

Circle in plane (enter radius)

Select two points on a plane:

Circle in plane (centre at 1st point)

Circle perpendicular to plane

Select three points (on a plane):

Circle; Centre of circle



SPHERE options

Attributes:

- Radius, r
- Surface area $= 4\pi r^2$
- Volume $= 4\pi r^3/3$

One point selected:

Sphere

Two points selected:

Sphere (1st point is the centre)



PARALLELEPIPED

Select 3 vectors and a point:

Parallelepiped

Scalar triple product $(\mathbf{a} \times \mathbf{b}) \cdot \mathbf{c}$ = volume of parallelepiped

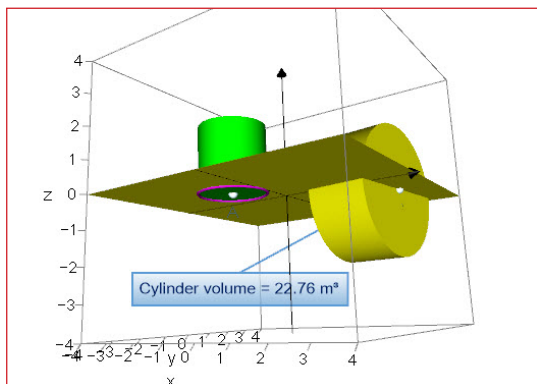


THE ATTRIBUTE CALCULATOR

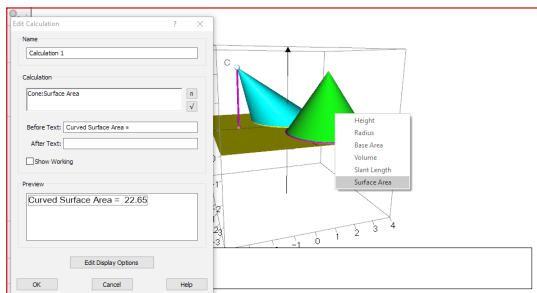
As in 2D, you can perform calculations using the attributes of objects on the page, or use it to display individual values of constants or attributes.



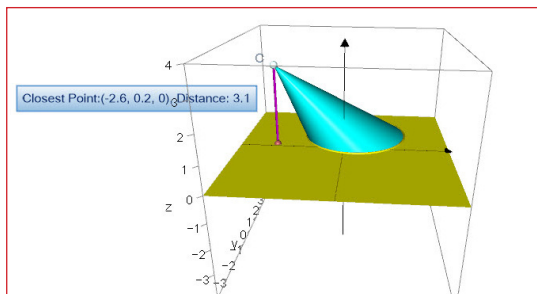
3D: CYLINDERS AND CONES



Cylinders can be drawn based on a circle or on two points. A calculator result is displayed here, always facing the front.



Using the calculator to investigate the attributes of a right cone.



A 'skewed' cone can be drawn, with a circle as its base, and a point as its vertex. Selecting this point and the plane of its base, you can use the option "Closest Point" to show the vertical height of the cone. The volume is also available, calculated as a third of the base area x the height.



CYLINDER options

Attributes:

- Height, h
- Radius, r
- Curved Surface Area = $2\pi rh$
- Top and bottom (if drawn) = $2\pi r^2$
- Volume = $\pi r^2 h$

Circle selected

Cylinder – enter height

Options: Infinite height, close bottom, close top

Two points selected:

Cylinder – enter radius



CONE options

Circle selected

Right Cone: enter height

Options:

- Close base of cone
- Paired cone
- Orientation

Attributes:

- Height, h
- Slant length, l
- Radius of base, r
- Curved Surface Area = πrl
- Area of base = πr^2
- Volume = $\frac{1}{3}\pi r^2 h$

Circle and one point selected

Skew cone

Options:

- Close base of cone
- Paired cone
- Orientation

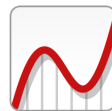
Attributes:

- Height, h
- Radius of base, r
- Area of base = πr^2
- Volume = $\frac{1}{3}\pi r^2 h$



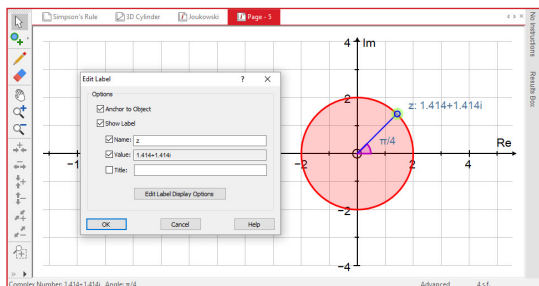
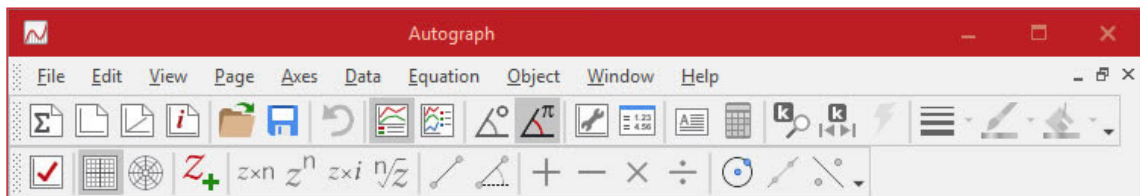
MANAGE CONSTANTS

As in 2D, you can assign a constant to an attribute: it is then controlled by the attribute, not the constant controller.

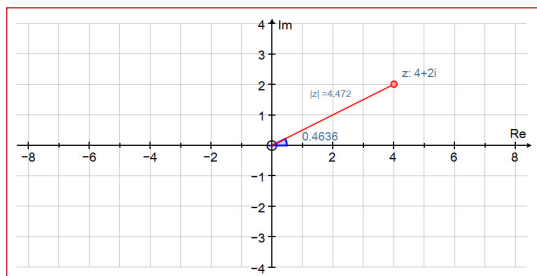




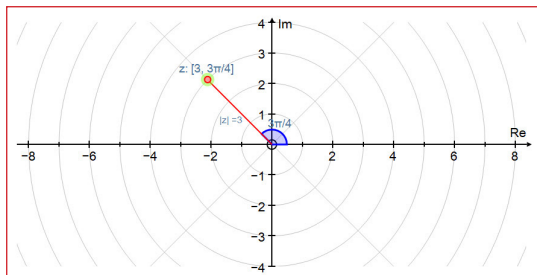
ARGAND DIAGRAM PAGE



An Argand Diagram page: circle radius 2 added, and a complex number, z , attached, which can be dragged round. Double-click on the label " z " to open "Edit Label".



Argand Diagram with rectangular axes



Argand Diagram with polar axes

This new page allows the dynamic exploration of complex numbers in the Argand Diagram.

TOP LEVEL OBJECTS:

[Return to v.4 Contents](#)



Enter Complex Number (see next page)

Option on entering a new complex number:
"Show vector to origin" (ticked by default)



Insert Image



Circle at O (enter radius)

Then objects dependent on the current selection

AXES options

Axes are labelled 'Re' ['Real'] and 'Im' ['Imaginary']



Equal Aspect on by default; radians only



Rectangular axes

Complex numbers can be controlled by arrow keys: 'x' and 'y'



Polar axes

Complex numbers can be controlled by arrow keys: 'r' and 'θ'
Use "Axes" -> "Snap Settings" to control this behaviour



Auto-scale:

This will adjust scales to show all complex numbers on screen

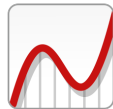
GENERAL POINTS:

New complex numbers are labelled z_1 , then z_2 , etc

Labels can be edited/hidden

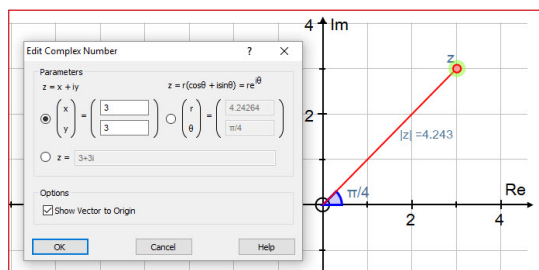
Right-click option to hide/unhide objects

i or j: both accepted

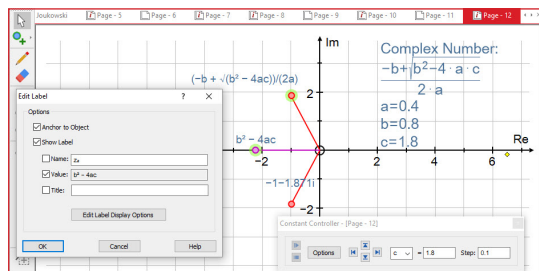


ENTERING A COMPLEX NUMBER

Complex numbers can be entered in rectangular or polar coordinates. Once entered, the number is plotted as a point.



Double-click on a complex number to reveal the edit dialogue, giving both cartesian and polar forms. Note the modulus and argument are being displayed (both right-click options).



Entering: $z = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

An example of a complex number being entered "z" form, including "±", "√" and "b²" (entered by typing +, ALT-R and ALT-2, or using the onscreen keyboard).

Here " $b^2 - 4ac$ " displayed by editing the label. Select the top number and use the Text Box to display the information on the right. Constant controller can vary 'a', 'b' and 'c'.

ENTER COMPLEX NUMBER

Right click option, or Press 'Enter'
Either [x, y] or [r, θ] or z = ...

These entries allow constants, which can be controlled dynamically using the Constant Controller

The "z = " entry

Input allows numbers, letters, trig, signs, ^, (,), |, cis, exp, √ and constants:

eg: $z = i$
 $z = a \operatorname{cis}(2\theta)$
 $z = 1+i$
 $z = 2 - 3i$
 $z = \sin\theta - i\cos\theta$
 $z = i^2$
 $z = \sqrt{1+i}$
 $z = a + ib$
 $z = (1+i)/(1-i)$
 $z = i(1+3i)$
 $z = (1+3i)^2$
 $z = r \exp(i\theta)$
 $z = r(\cos\theta + i \sin\theta)$
 $z = r(\exp(i\theta) + \exp(-i\theta))/2$ $[= r \cos\theta]$
 $z = r(\exp(i\theta) - \exp(-i\theta))/(2i)$ $[= \sin\theta]$

Expressions involving ±

These create TWO CNs, one with "+" and a dependent "-"

eg: $z = \pm 2$ [both real]
 $z = 2 \pm 2i$ [complex conjugate pairs]
 eg: $z = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
 [complex conjugate pairs when $b^2 < 4ac$]

Convention

Place 'i' AFTER a number, but BEFORE algebraic terms.

eg: $3 - 3i$, $\cos\theta + i \sin\theta$

POINT MODE

Creates a Complex Number where you click, and this can be dragged about, together with any dependent complex number that have been created from it.

Double-click on any complex number to edit it - in cartesian, or polar form.



Multiplying z by a scalar (2) and by i (rotating through $\pi/2$)

A visualisation of De Moivre's Theorem, showing z and z^2 on polar axes. Use "Edit Label" to show the polar coordinates.

The n th roots of 4: above 3, below 4.



⚡ You can select one of the roots and use “Animate” to vary the number of roots dynamically.

SINGLE COMPLEX NUMBER selected

Right Click options:



1. Edit Complex Number

However the CN has been entered (rectangular coordinates, polar coordinates or $z = \dots$) this will confirm its coordinates in both rectangular and polar form:

Rectangular:	Modulus:	$r = \sqrt{x^2 + y^2}$,
	Argument:	$\theta = \arctan(y/x)$
Polar:	Real part:	$x = r \cos \theta$
	Complex part:	$y = r \sin \theta$



2. Multiply by scalar – enter factor

eg $z = a + bi \Rightarrow 2z \Rightarrow 2(a + bi)$
 $kz \Rightarrow k(a + bi)$

If a constant used, the constant controller can animate
Alternatively a selected scaled CN can be animated



3. Raise to power – enter positive or negative integer

eg $z = (r, \theta)^n \Rightarrow z^n \Rightarrow (r^n, n\theta)$

If a constant is used, the constant controller can animate
Alternatively a selected scaled CN can be animated



4. nth Roots – enter n

eg $z = (r, \theta) \Rightarrow (r^{1/n}, (\theta + 2\pi m)/n)$

creates n new dependent Complex Numbers

for $m = 0, 1, 2, \dots, n-1$

A selected set of n th roots can be animated



5. Multiply by i [rotates anti-clockwise 90°]

eg $z = i(a + ib) \Rightarrow iz \Rightarrow -b + ia$

6. Complex Conjugate, z^*

eg $z = a + ib \Rightarrow z^* \Rightarrow a - ib$

7. Real Part

eg $z = a + ib \Rightarrow \text{Re}(z) \Rightarrow (a, 0)$

8. Imaginary part

eg $z = a + ib \Rightarrow \text{Im}(z) = (0, b)$



9. Argument (marked, in radians)

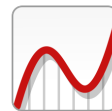


10. Modulus (marked as $|z|$)

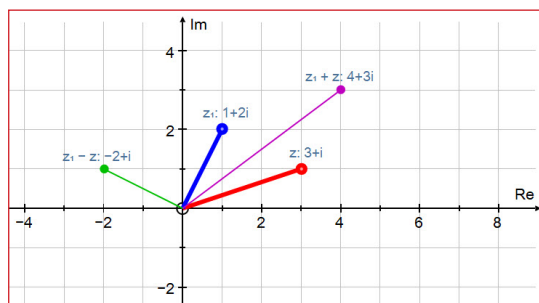


11. Circle (centred on the Complex number) - enter radius.

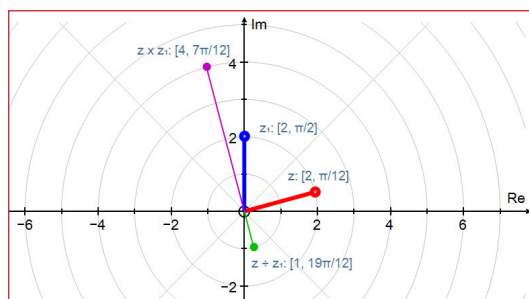
Select the circle for 'complex transformation'.



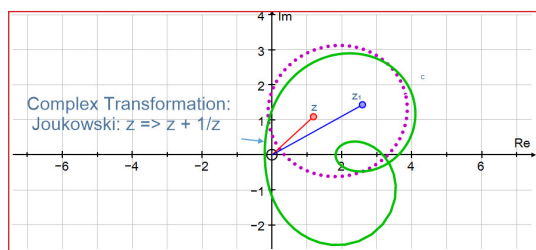
OPTIONS FOR TWO COMPLEX NUMBERS



Using rectangular coordinates to illustrate adding and subtracting two complex numbers. Use "Edit Label" to show the values.



De Moivre's Theorem in action: illustrating multiplication and division of two entered complex numbers. Either of the parent numbers can be moved about the scene, or, selected, by using the arrow keys to vary "r" or "θ".



A Joukowski transformation of an ellipse based on two parent complex numbers as the foci. Here the associated text box provides on-screen information and an arrow.

Use "Edit Draw Options" to adjust appearance of the objects.

TWO COMPLEX NUMBERS SELECTED

$$z_1 = a_1 + ib_1 \Rightarrow (r_1, \theta_1)$$

$$z_2 = a_2 + ib_2 \Rightarrow (r_2, \theta_2)$$

Right Click options:

- +** 1. Addition:
 $z_1 + z_2 \Rightarrow (a_1 + a_2) + i(b_1 + b_2)$
- 2. Subtraction:
 $z_1 - z_2 \Rightarrow (a_1 - a_2) + i(b_1 - b_2)$
- x** 3. Multiplication:
 $z_1 * z_2 \Rightarrow (a_1 * a_2 - b_1 * b_2) + i(a_2 * b_1 + a_1 * b_2)$
 $\Rightarrow (r_1 * r_2, \theta_1 + \theta_2)$
- ÷** 4. Division:
 $z_1 / z_2 \Rightarrow (r_1 / r_2, \theta_1 - \theta_2)$



- 5. Straight Line joining them:
Select the line for 'complex transformation'

- 6. Ellipse with the two Complex Numbers at each focus
Select the ellipse for 'complex transformation'

TWO OR MORE COMPLEX NUMBERS SELECTED

- +** Right Click option: **Addition:**
 $z_1 + z_2 + z_3 + \dots \Rightarrow (a_1 + a_2 + a_3 + \dots) + i(b_1 + b_2 + b_3 + \dots)$

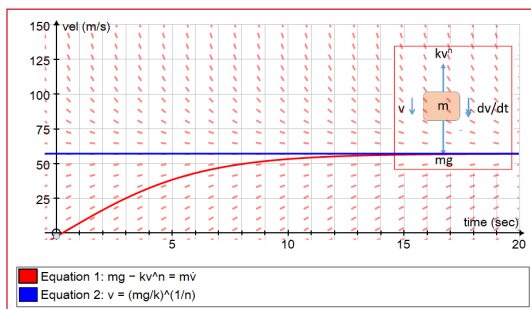
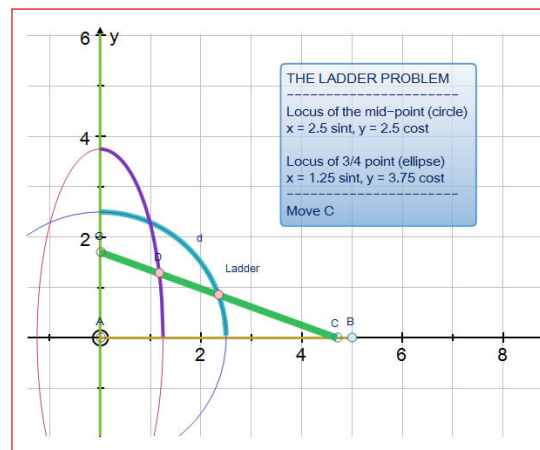
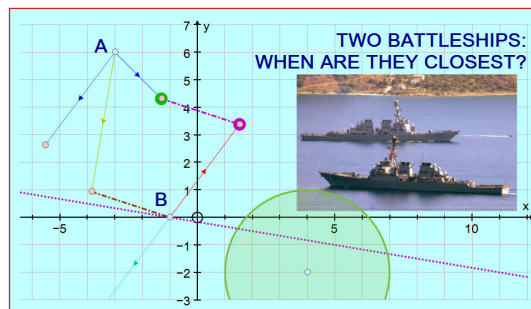
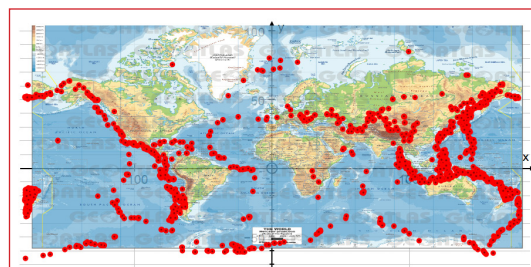
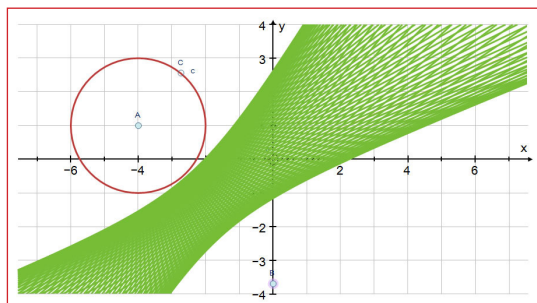
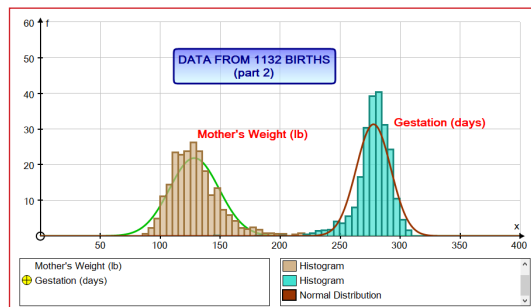
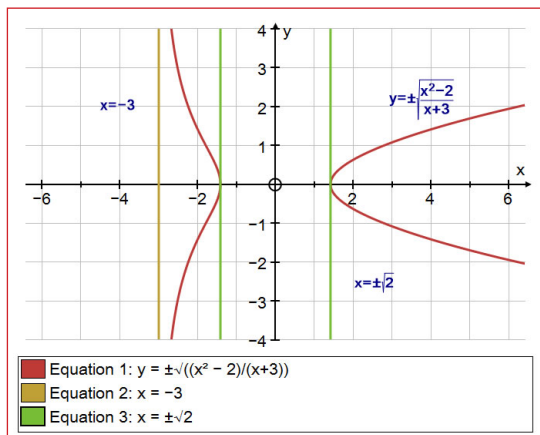
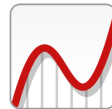
TRANSFORMATIONS OF COMPLEX NUMBERS

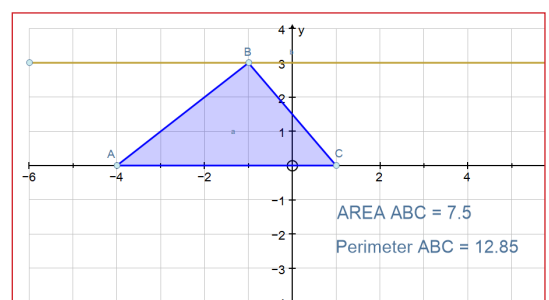
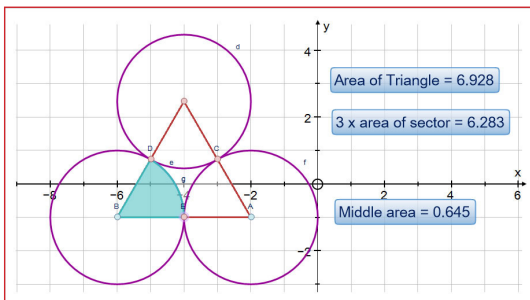
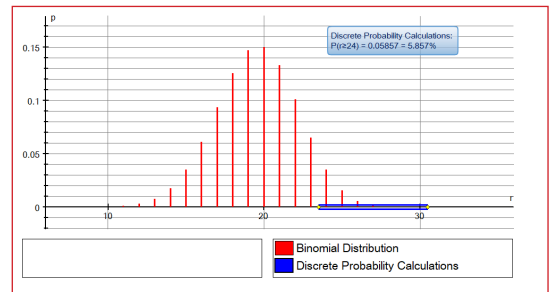
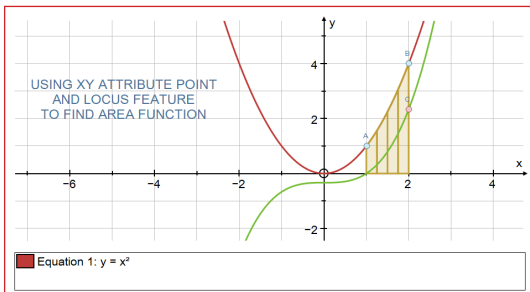
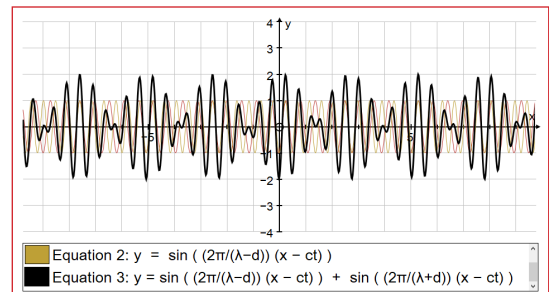
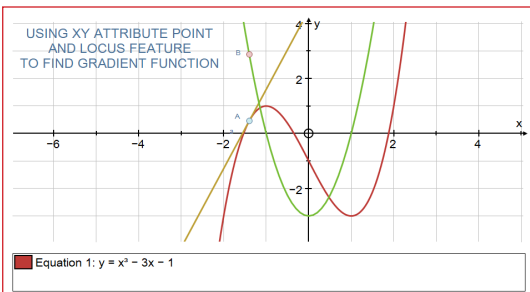
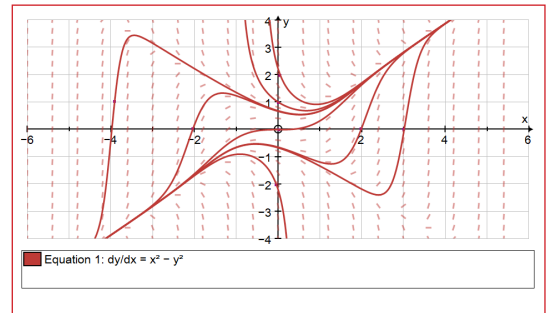
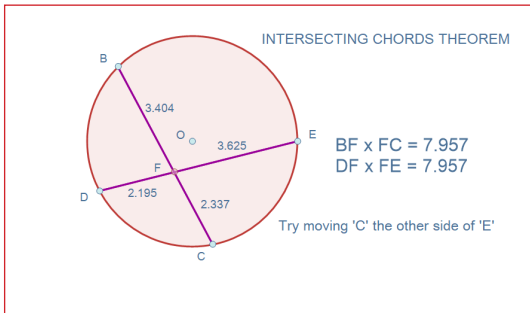
Select an existing CIRCLE locus, ELLIPSE locus or LINE locus
Choose from the following:

Conjugation	$z \Rightarrow z^*$
Sine	$z \Rightarrow \sin(z)$
Cosine	$z \Rightarrow \cos(z)$
Exponential	$z \Rightarrow \exp(z)$
Inversion	$z \Rightarrow 1/z$
Joukowski	$z \Rightarrow z + 1/z$
90° Rotation	$z \Rightarrow iz$

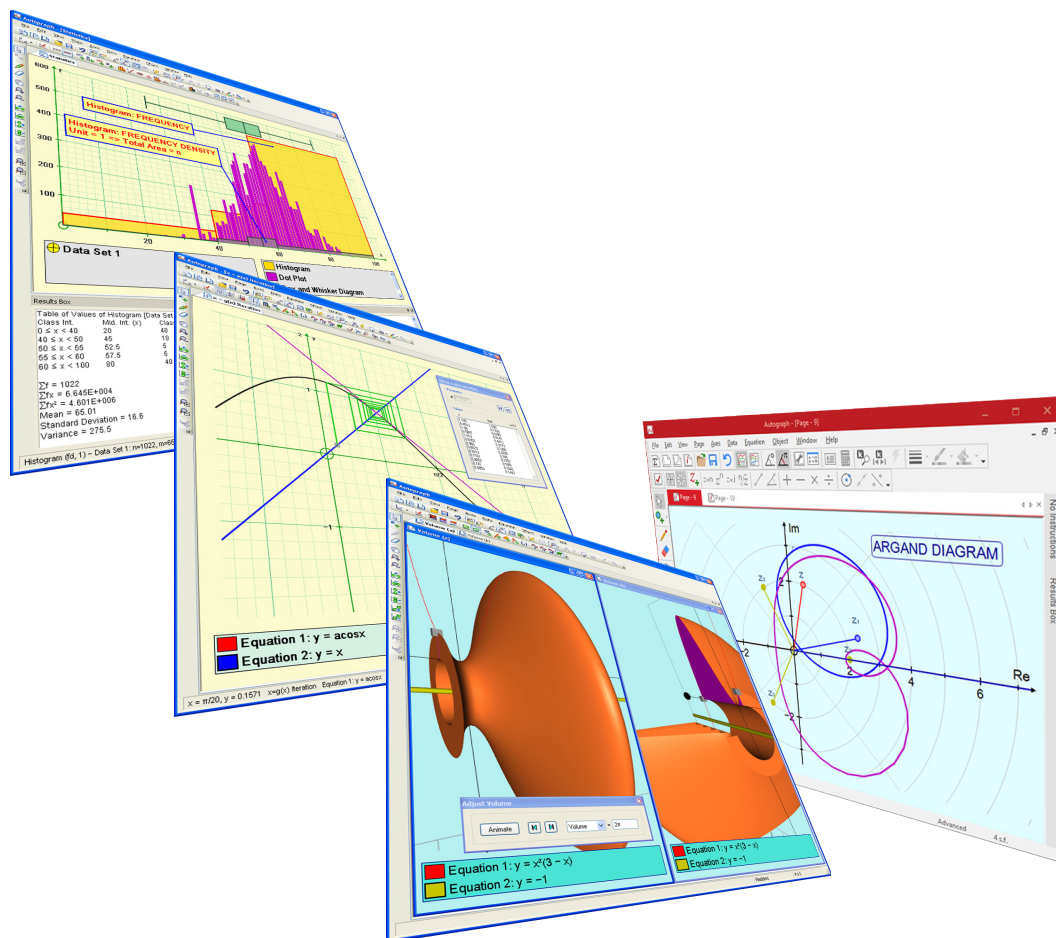
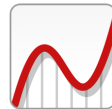
Freeform: $z = \dots$
[use "real(z)" and "imag(z)" if required]







Autograph



Autograph Manual Extension (Draft: 14th November 2017)

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[LINK to v.3 Manual](#)