GeoGebra Functions

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Activity 1: <u>Introduction GeoGebra Functions</u>

To download GeoGebra go to www.geogebra.org and the following window will appear.
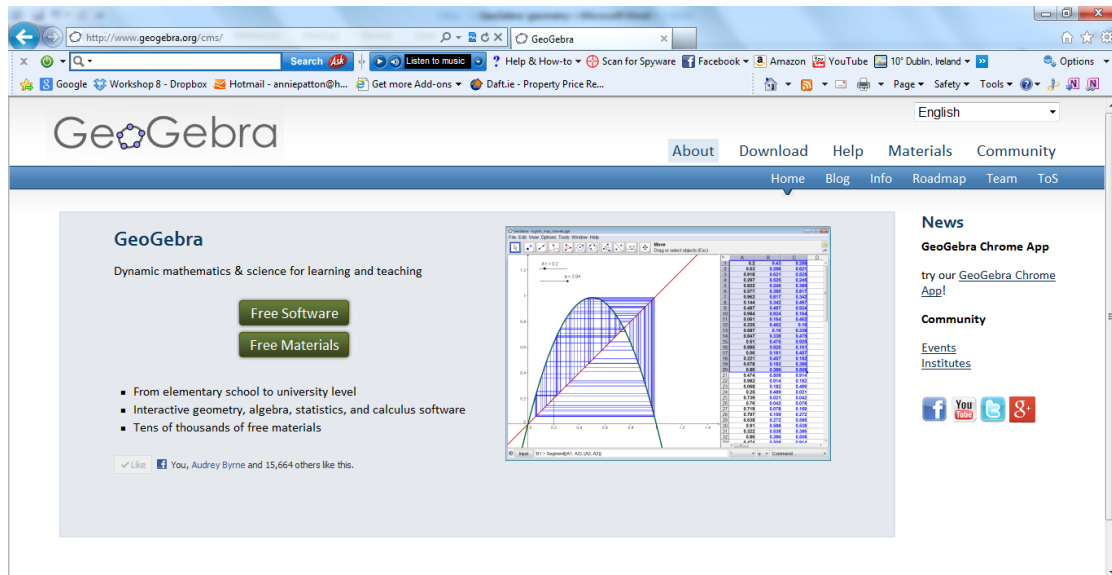

Click Free Software and the following window will appear.
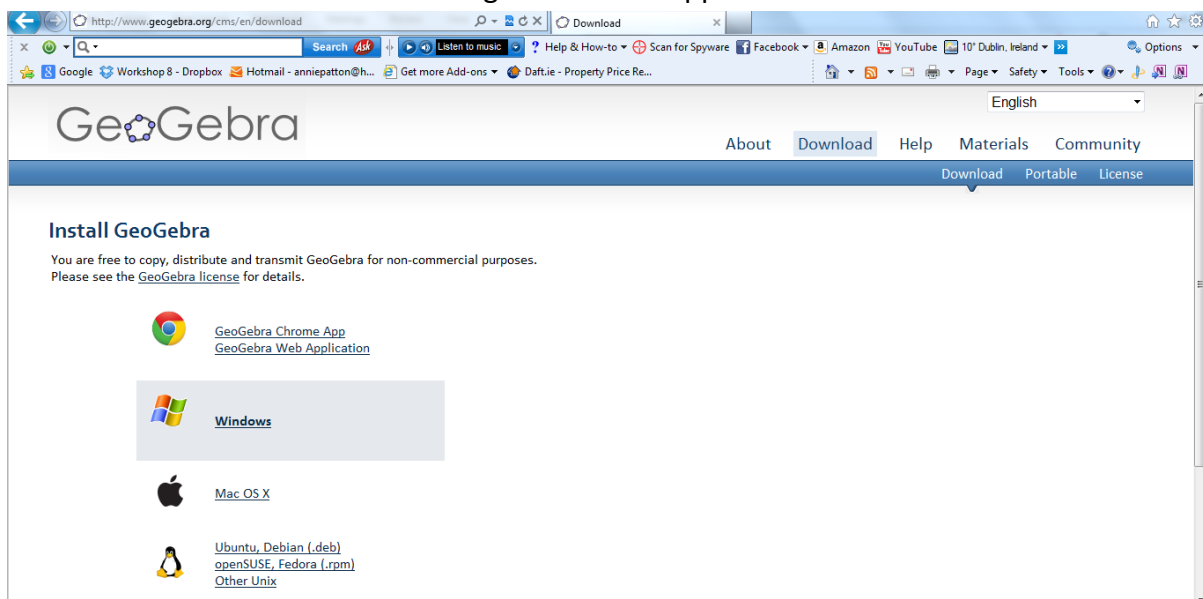
Click the platform suitable for your computer and follow the indicated steps to download GeoGebra.

Note: In order to run GeoGebra it is essential that an up to date version of Java is available on your machine. This package is available at free at http://www.java.com/en/ .
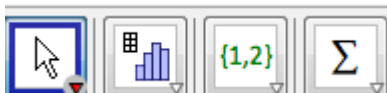
In GeoGebra there are three Views, Algebra, Graphics and Spreadsheet. The bar containing File, Edit etc. is known as the Menu bar.
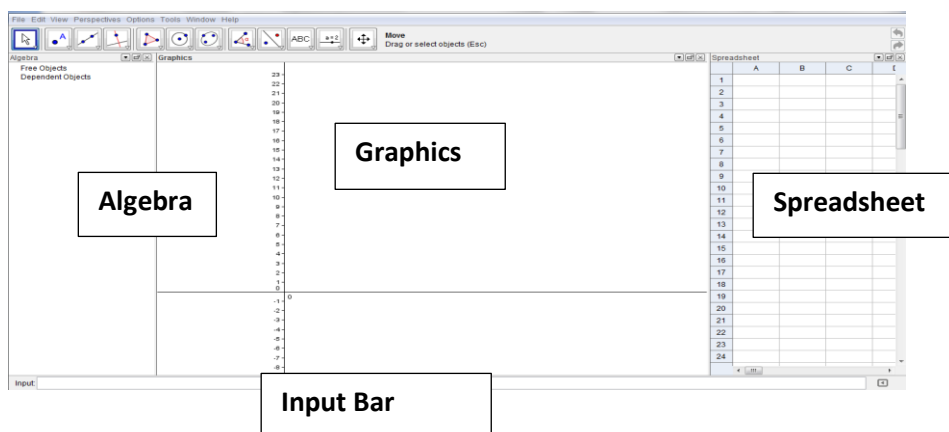
Note: When you click on the Graphics View the following toolbar appears:

and when you click on the Spreadsheet View the following toolbar appears:

Note: If the Spreadsheet View is not visible go to View and click Spreadsheet and if the Graphics View is not visible go to View and choose Graphics.

Note: When drawing a function use $f(x) =$ rather than $y =$, because when $y =$ is used some of the commands from the Input Bar do not work for the function.
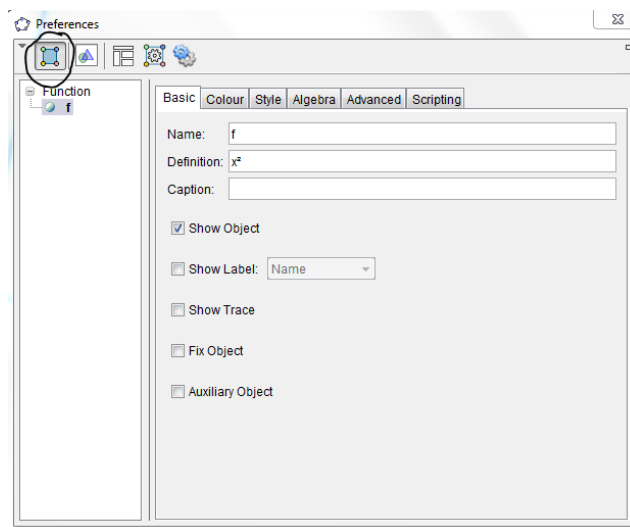
Activity 2: To draw the function f(x)=x²
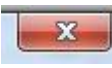
1. Open GeoGebra.
2. In the Input Bar type $f(x) = x^\wedge 2$ and press Enter on the keyboard. Pressing the Shift key and the 6 key simultaneously on the keyboard gets ^.
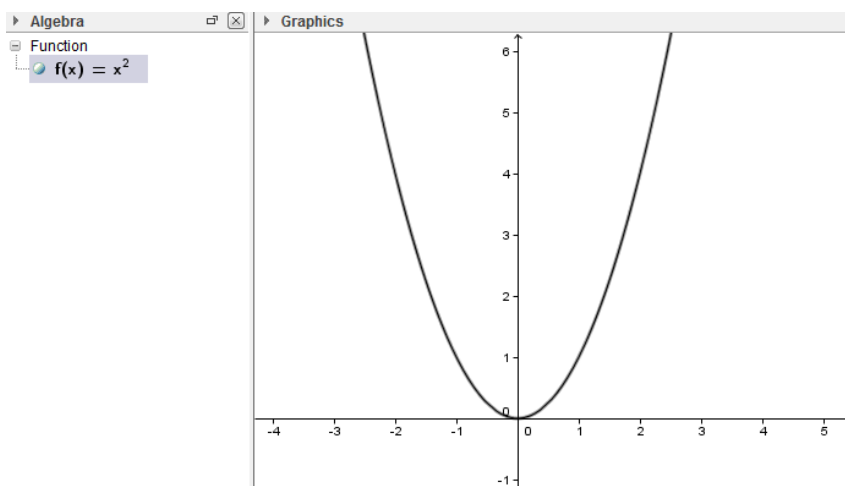
Activity 3: **To change the colour, etc. of a graph of a function**

1. Click on the graph of the function, right click and choose Object Properties. A new dialogue box appears.


2. With the Properties tool open choose the Colour tab to change the colour and choose the Style tab to change the style of the line.

3. With the Basic tab open, click the Show Label button and choose Name and Value from the drop down menu to enable the name of the graph of the function and its equation both to be shown. Click at the top of this window.

Activity 4: **To draw the graph of the quadratic function f(x) = ax^2+bx+c**
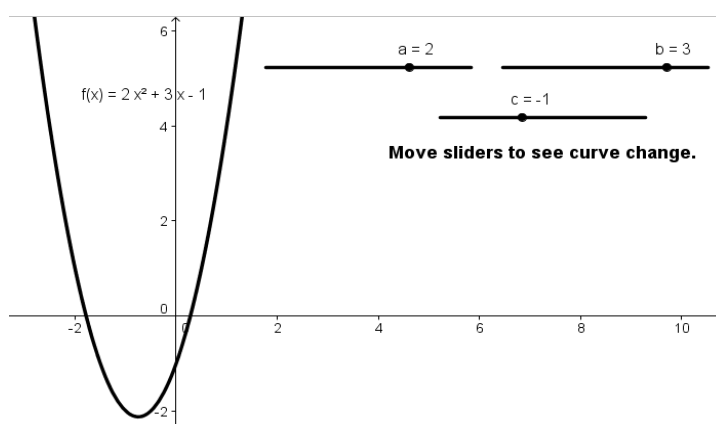

1. Go to File and choose New Window.

2. Select the Slider tool . Click on the Graphics View and create a slider called a with min: = -5, max: = 5 and Increment: = 1.

3. Select the Slider tool [a = 2]. Click on the Graphics View and create a slider called b with min: = -5, max: =5 and Increment: = 1.

4. Select the Slider tool [a = 2]. Click on the Graphics View and create a slider called c with min: = -5, max: =5 and Increment: = 1.

5. In the Input Bar type f(x)=a x^2+b x+c Note: The spaces can be replaced by an *.

6. Move the sliders and see how the graph of the function changes.

Explorations:

What is the effect of changing the "a" slider?
What is the effect of changing the "b" slider?
What is the effect of changing the "c" slider?

7. Open the Algebra View if it is not already open (Go to View and click Algebra) and watch the value for f(x) change as the sliders change.

8. In order to see the value of the function in the Graphics View, right click the graph of the function and select Object Properties. With the Properties tool [icon] clicked and the Basic tab open click the Show Label button and select Name and Value from the drop down menu. Click [X] at the top of the dialogue box.
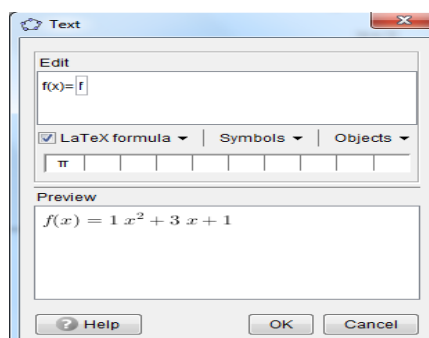
Alternatively to see the equations change in the Graphics View:

1. Select the Text tool [ABC] and click on the Graphics View at the position you want the formula for the graph of the function to appear. A new dialogue box appears.
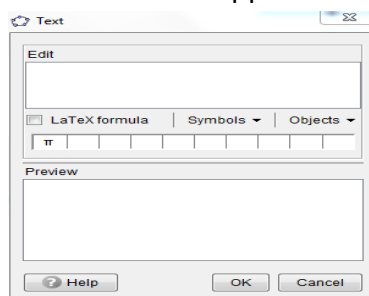
2. Type the following text "f(x) =" in the Edit section and select f from the drop down menu under Objects and click OK.

Activity 5: <u>To animate the above graph of the function using the slider a</u>

1. Right click on slider a and choose Animation On.

2. A new icon ⏸ will appear at the bottom left hand corner of the Graphics View. Click on this icon to stop and start the animation.

Activity 6: <u>To export an animated slide to PowerPoint</u>

1. Make the GeoGebra file using a slider as normal. For example the slider a and the function f(x) = a x+1.
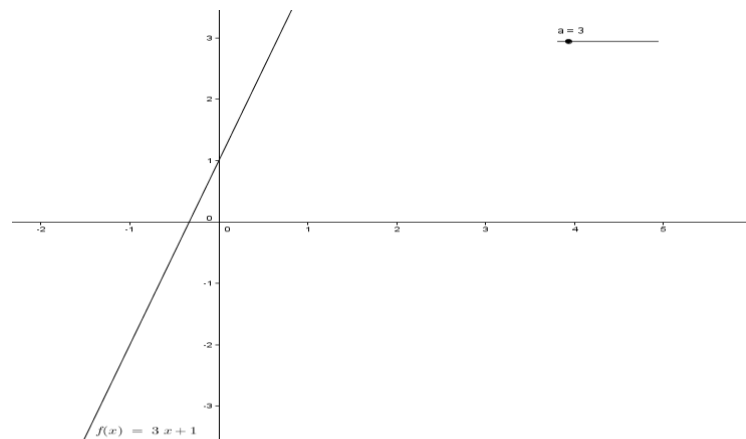
2. Save the file, by going to File and Save As.
3. Go to File, Export and Graphics View as an Animated GIF. A new window appears.
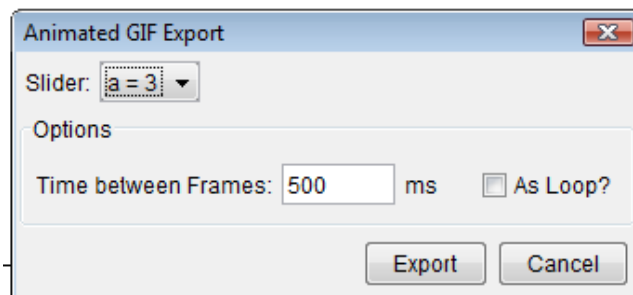
4. Choose the slider you require to be animated by following the drop down menu beside Slider. To enable the animation to continue infinitely click the As Loop box. Choose the Time between Frames and click Export.

Note: The exporting of this gif can be slow.

5. Open PowerPoint and insert your picture in the usual way depending on the version of PowerPoint you have.
6. View the slide show.

## Activity 7: <u>To investigate a quadratic of the form f(x) = a*(x+b)^2+c</u>
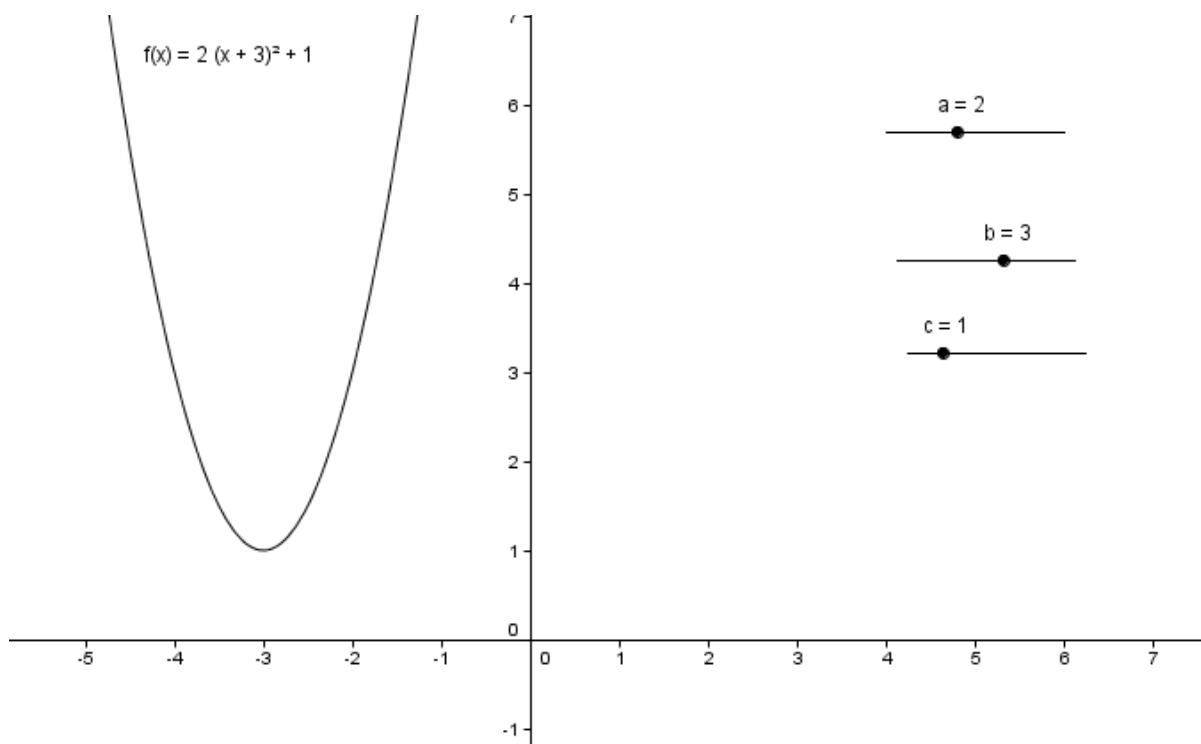
$f(x) = 2\,(x + 3)^2 + 1$

$a = 2$

$b = 3$

$c = 1$

1. Go to File and choose New Window.

2. Select the Slider tool [a = 2]. Click on the Graphics View and create a slider called a with min: = -5, max: = 5 and Increment: = 1.

3. Select the Slider tool [a = 2]. Click on the Graphics View and create a slider called b with min: = -5, max: =5 and Increment: = 1.

4. Select the Slider tool [a = 2]. Click on the Graphics View and create a slider called c with min: = -5, max: =5 and Increment: = 1.

5. In the Input Bar type f(x)=a(x+b)^2+c Press Enter on the keyboard.

6. Move the sliders and see how the graph of the function changes.

Explorations:

What is the effect of changing the "a" slider?

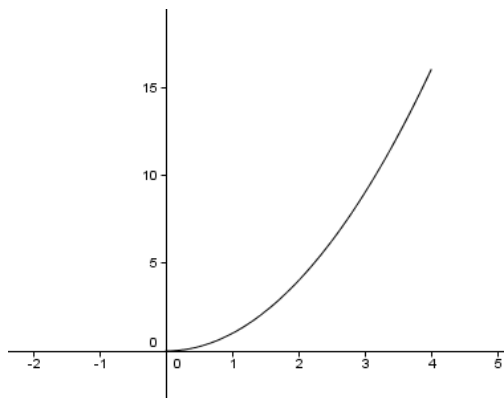What is the effect of changing the "b" slider?

What is the effect of changing the "c" slider?

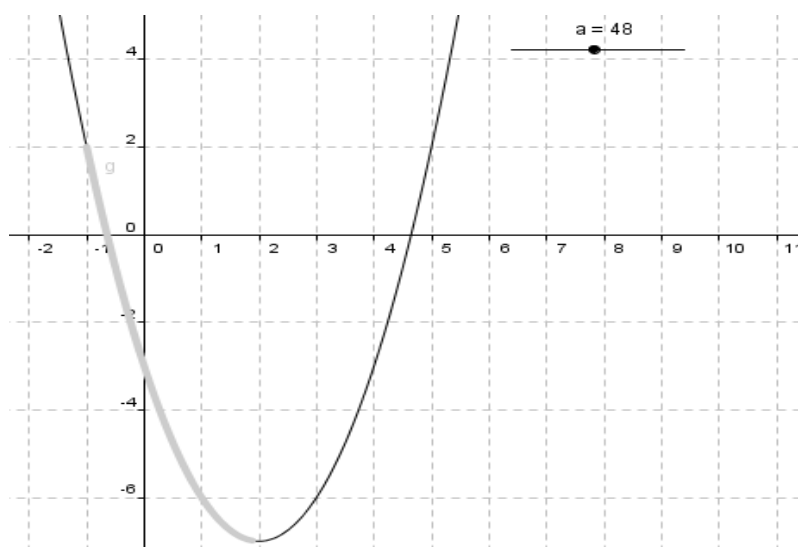## Activity 8: To draw a section of a function

1. Go to File and choose New Window.
2. In the Input Bar type Function[x^2, 0,4].

Input: function[x^2,0,4]

3. Press Enter on the keyboard.

Activity 9: To show a function appearing bit by bit

1. Go to File and choose New Window.
2. In the Input Bar type the f(x)=x^2-4 x-3 to create the function f(x) = x^2-4x-3.
3. Hide the function f. (Right click the function f and click Show Function.)
4. In the Input Bar type start=−1. Press Enter on the keyboard.
   In the Input Bar type end=5. Press Enter on the keyboard.
   This is defining two numbers. The numbers could be called anything e.g. a and b, but start and end make more sense later.

5. Select the Slider tool [a = 2]. Click on the Graphics View and create a slider called a with min: = 0, max: = 100 and Increment: = 1. Click OK to close the slider dialogue box.

6. In the Input Bar type function[f,start,start+(end-start)/100 a]. Press Enter on the keyboard. Note: The space between 100 and a. This draws a new function which is the old function divided into 100 parts and can be revealed one part at a time.

function[f,start,start+(end-start)/100 a]

| The part of the function to the right of start is being divided into 100 pieces. | If your slider a=23 then 23 of the 100 pieces of the function to the right of start will be shown |

7. Adjust the value of the slider a to reveal the function in sections.

8. Right click on the function g and choose Object Properties and with the colour tab open change the colour of function g.

Note 1: You can change the values of the start and end numbers later by double-clicking on them in the Algebra View or by typing e.g. start=2 into the Input Bar.

Note 2: slowplot[f] will do the same as the above, except the domain will be the visible portion of the Graphics View.

Activity 10: <u>Find where a graph of a function and a line meet</u>

1. Go to File and choose New Window.
2. Draw the quadratic function f(x) for example $f(x)=x^2+3x+2$ and the line g(x) for example g(x)=2x+3.

$f(x) = x^2 + 3x + 2$

$g(x) = 2x + 3$
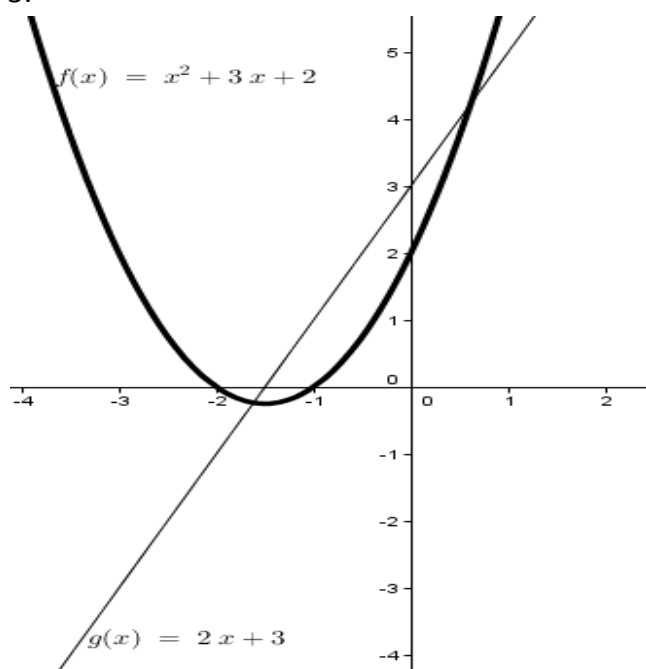
3. Select the Intersect Two Objects tool ![tool icon]. Click on the graph of the function and the graph of the line to find their points of intersection.
   Point(s) will appear at the intersection of the line and the graph of the function.

   Another method is in the Input Bar type Intersect[f,g] and press Enter.

## Activity 11: <u>To draw the graph a cubic function using sliders</u>
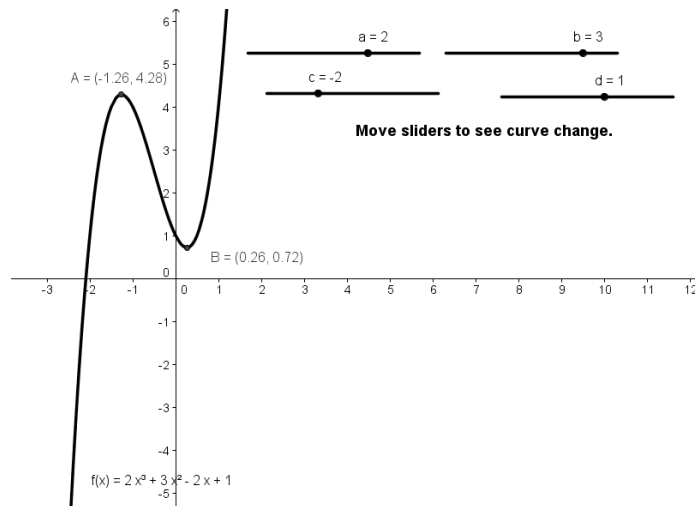
1. Go to File and choose New Window.

2. Select the Slider tool ![slider icon]. Click on the Graphics View and create sliders a, b, c and d.

3. In the Input Bar type f(x)=ax^3+bx^2+cx+d. Press Enter on the keyboard.
   Note: If you already know the equation of the cubic for example f(x)=2x^3+3x^2+1x+1, just type f(x)= 2x^3+3x^2+1x+1 into the Input Bar and press Enter on the keyboard. You can also enter equations like f(x)=(x-2)(x+2)(x-1) in the Input Bar.

Activity 12: <u>Highlighting where one function is above another function</u>
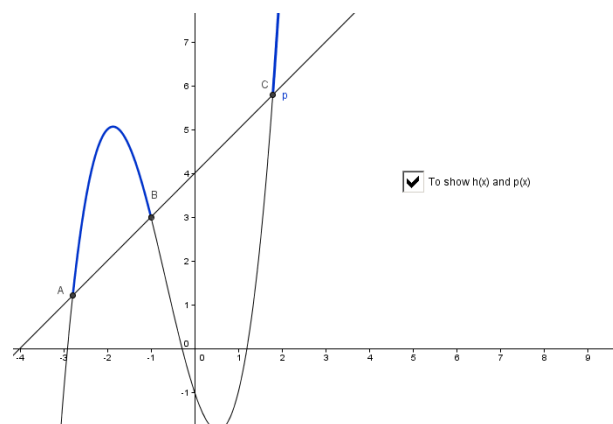
1. Go to File and choose New Window.

2. In the Input Bar type f(x)= x^3+2x^2–3x–1 to create the function
   $f(x) = x^3 + 2x^2 - 3x - 1$.

3. In the Input Bar type g(x)=x+4 to create the function g(x)=x+4.

4. Type Intersect[f,g] in the Input Bar and press Enter on the keyboard which creates

   three points A, B and C. Alternatively use the Intersect Two Objects tool .

5. Type Function[f,x(A),x(B)] in the Input Bar.
   A function called h(x) = x^3+2x^2-3x-1 now appears in the Dependant Objects list in the
   Algebra View. Right click on h(x) in the Algebra View and change the colour of this to
   blue and its line style to be thicker.

6. Input Function[f,x(C), ∞]
   To type the symbol ∞ click the α on the right hand side of the Input Bar and choose
   ∞.
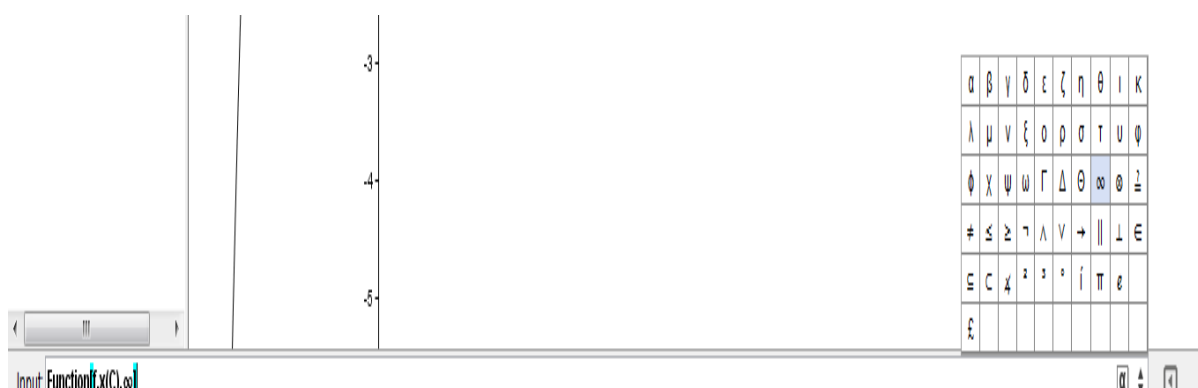
   A function called p(x) = x^3+2x^2-3x-1 now appears in the Dependant Objects list in the
   Algebra View. Right click on h(x) in the Algebra View and change its colour and line
   thickness to that of h(x).

7. Create a checkbox to show/hide h(x) and p(x). To do this select the Check Box to

   Show /Hide Object tool . Click on the Graphics View and when the dialogue
   box appears type in some suitable text and then from the drop down menu under
   Select objects in construction or choose from list select h(x). Repeat this procedure
   for a Tick box to show/hide p(x).
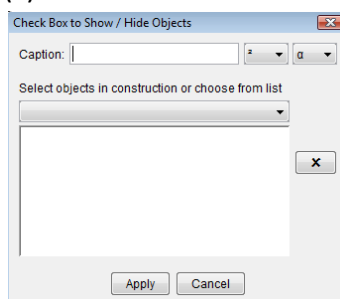
Activity 13: Turning Points, Roots, Derivatives, Second Derivatives and Integrals

1. Go to File and choose New Window.
2. In the Input Bar type f(x) = x^3+x^2-3x-2.
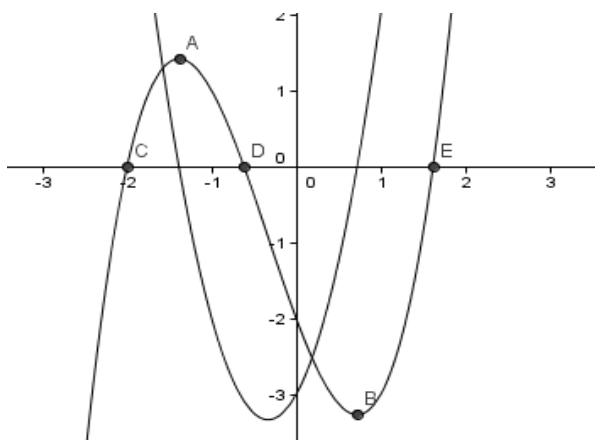3. To find the turning points A and B in the Input Bar type TurningPoint[f].
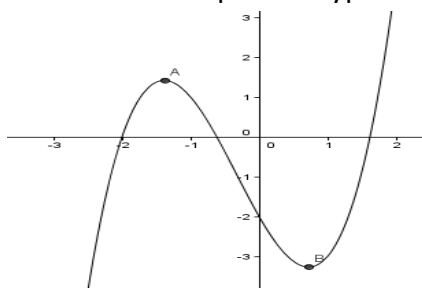
Note 1: If the language is set to English (US) then you will have to use Extremum[f].

Note 2: By right clicking the points A and B and choosing Object Properties you can change the names of the Turning Points to something more suitable such as turn1 and turn2.

4. To draw the points where the function f crosses the x axis or the roots of the function f in the Input Bar type root[f].
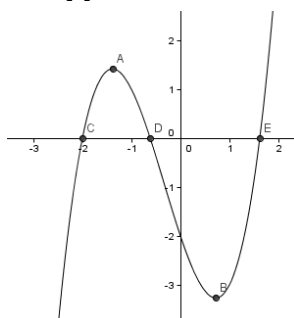
5. To draw the derivative of f in the Input Bar type derivative[f]. This creates a new function called f'(x).

Note: An alternative here would have been to type f'(x) into the Input Bar.

6. If you wanted to compare f'(x) with f(x) then type root[f']in the Input Bar and look at the x values of the roots of f'(x) and the turning points of f(x).

7. To graph the second derivative of f in the Input Bar type derivative[f']. This creates a new function called f''(x).

   Note: An alternative here would have been to type f''(x) into the Input Bar.

8. In the Input Bar type Integral[f'']. This draws the integral of f''(x) and names it g(x). It is very similar to the graph of f'(x). f'(x)=3x^2+2x-3 and g(x)= 3x^2+2x.

   Note 1: The integral[] command doesn't add in the "c" bit of the integration.

   Note 2: Use of colour and show/hide checkboxes can make things a little clearer here.

Activity 14: To demonstrate derivative and slope
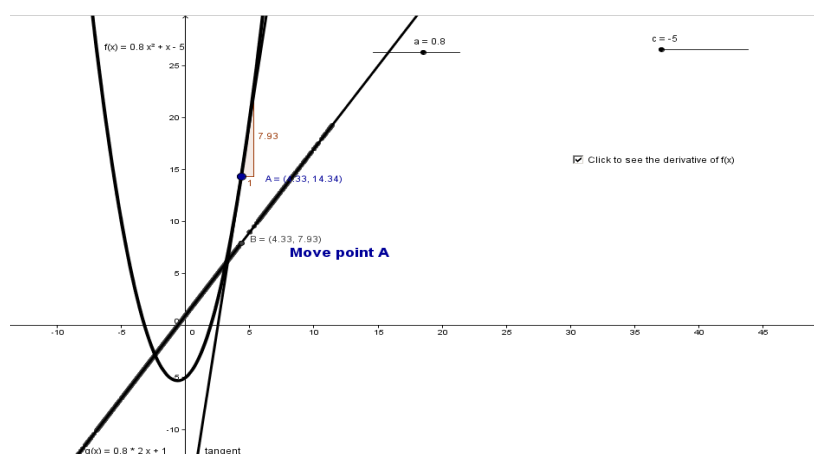
1. Go to File and choose New Window.

2. Select the slider tool ![a = 2]. Click on the Graphics View and create a slider called a.

3. Select the slider tool ![a = 2]. Click on the Graphics View and create a slider called c. Note: You need to put c for the name of the slider.

4. By typing f(x) =a x^2+x+c in the Input Bar create a quadratic. Note the space between a and x. This prevents the function being (ax)^2+x+c.

5. Right click on the graph of the function and go to Object Properties and change the colour and the style of the graph of the function as required.

6. Select the Point on Object tool ![point tool] . Click on f and create a point A on f(x).

7. In the Input Bar type Tangent[A, f].
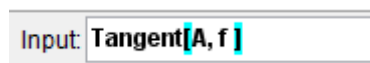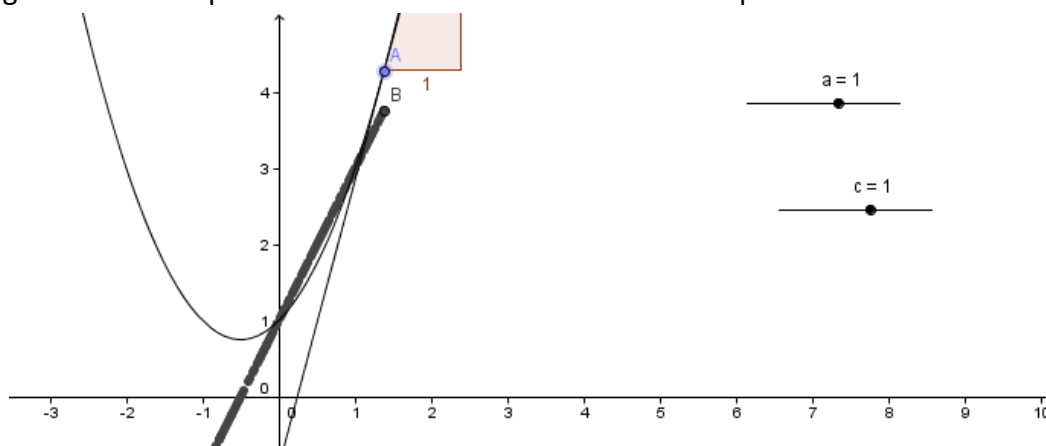
Input: Tangent[A, f]

8. To find the slope of the tangent at the point A. Select the Slope Tool [icon]. Click on the Tangent.
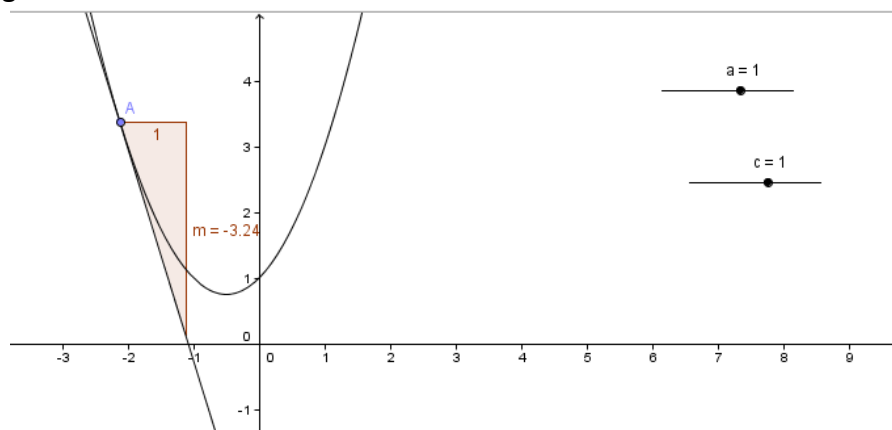
9. To create a point B, type B=(x(A), m) in the Input Bar and press Enter on the Keyboard.
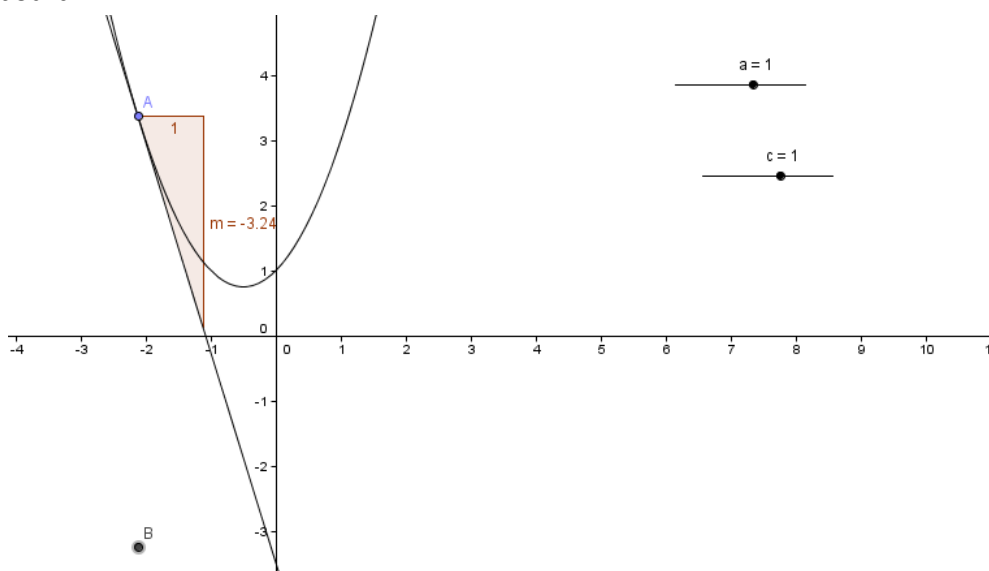
10. Right click on the point B and click the Trace on. Move the point A.

11. In the Input Bar type f'(x). Note the relationship between the trace as you drag point A and the graph of the function of f'(x).

12. Select the Check Box to Show / Hide Object Tool . Click on the Graphics View and Complete the new dialogue box that appears as follows:
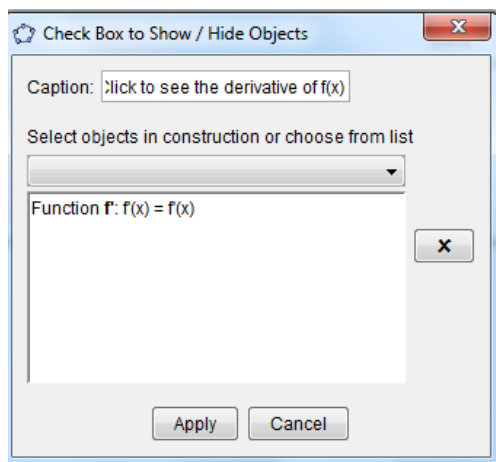
13. Click Apply.
14. Move the point A.

Note 1: The route of the trace of the point B follows the f'(x) which is the derivative of f(x).

Note 2: Clicking View and Refresh Views will clear the trace.

Activity 15: Function Inspector Tool

Note when the keyboard is mentioned in these notes you can use the keyboard on your machine or the virtual keyboard supplied with GeoGebra. See Appendix B of these notes on how to access this keyboard.

1. Draw a function for example $f(x) = (x - 2)(x - 1)(x + 1)$, by typing $f(x) = (x - 2)(x - 1)(x + 1)$ in the Input Bar at the bottom of the screen and press Enter on the keyboard.
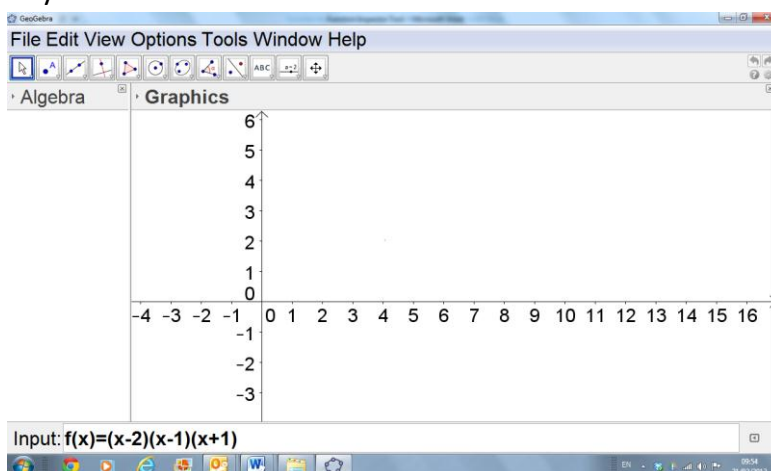
2. In the third set of tools from the right of the toolbar click on the Function Inspector tool .
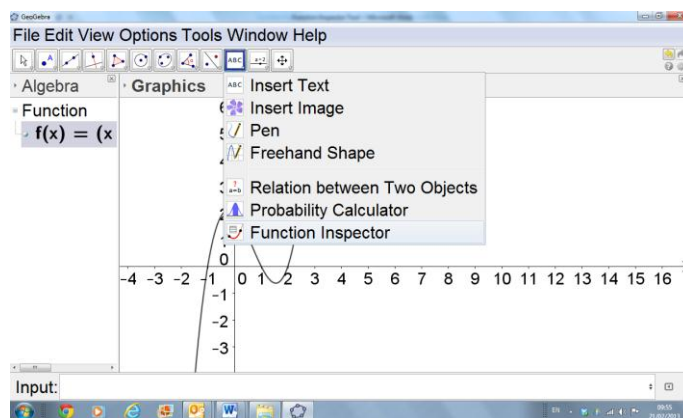
3. Select the function in the Graphics View that you want details of. In this case click on $f(x) = (x - 2)(x - 1)(x + 1)$.

4. A new window appears. (Watch this may contain settings from your previous use of GeoGebra.)
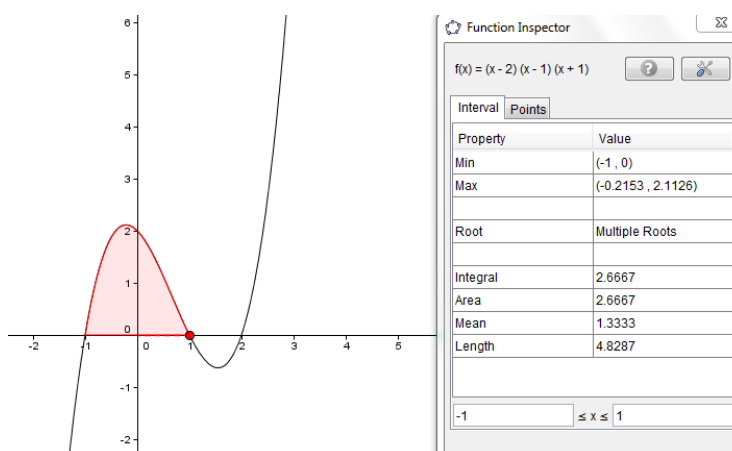
5. With the Interval tab open type the interval you want to examine for example $-1 \leq x \leq 2.5$.

   N.B. <u>You must press the Enter button on your keyboard after each number for it to take effect</u>.

6. The interval is marked on the curve in red and the information like Min, Max, Root, Integral and Area are now given for that interval in the table.
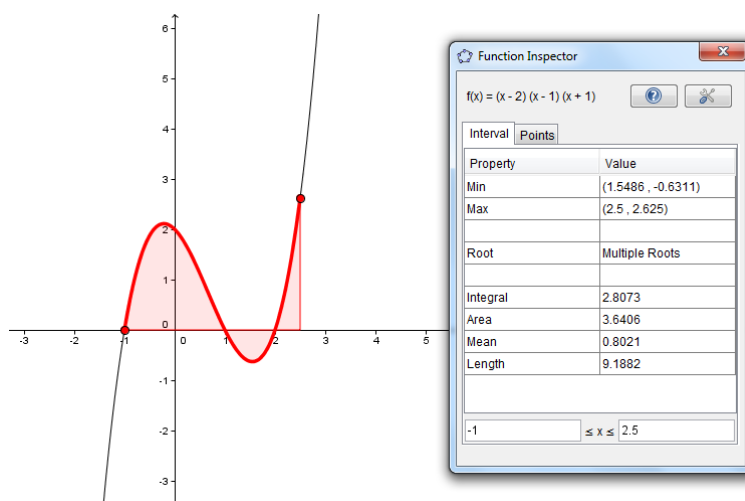
Note: The Max and the Min that is given in this table is the maximum value and minimum value of the function <u>in the interval that the Function Inspector is investigating</u>.

7. The Mean is the "Average value" of the function. It is the area underneath the curve divided by the length of the interval.

8. If you do not wish the interval to be shown on the Graphics View, you can right click on this section of the function and deselect Show Object.
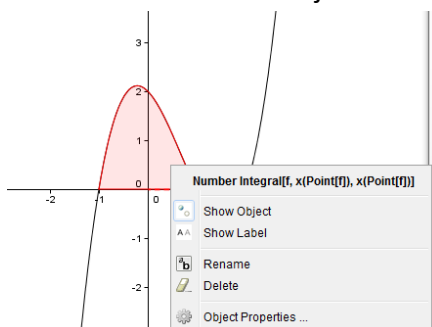
9. Open the Points Tab.
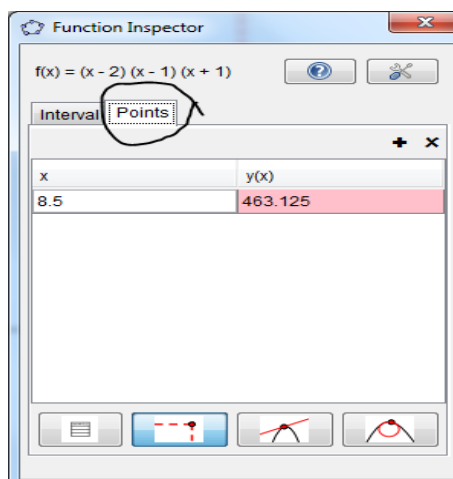
Note: If the point shown on the table above is not visible on the Graphics View replace it with a value that is visible.

10. Click on the Show table of points button . Notice the x and $y(x)$ values appear on the table.
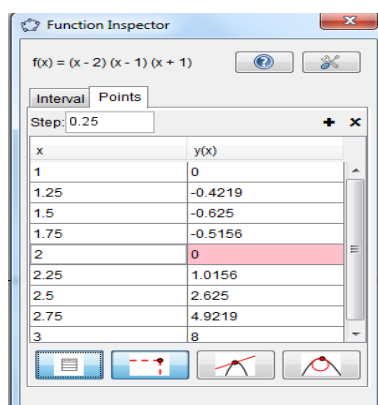
11. Note the point that is highlighted in the table will have a red dot on the graph.
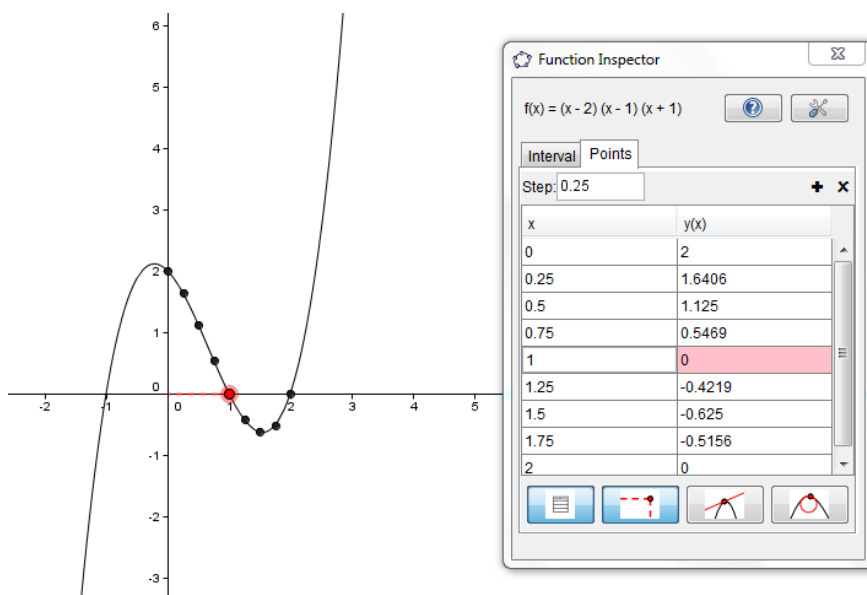
12. To change the Step to 1. Delete the current value using the Backspace button on your keyboard, press 1 and Enter on the keyboard.

13. To change the values in the table, move the red point on the Graphics View that now appears on the curve until the required points appear in the table. Four points to the right and four to the left of the red point will appear on the table.

14. If you just require integer values for the x co-ordinate go to Options, Point Capturing and choose Fixed to Grid. Move the red dot on the Graphics View. You can also double click on the x coordinate of the point highlighted in the table and type in the number you want.

15. By clicking on Show tangent line button tool you can show the tangent at the point highlighted in the table.
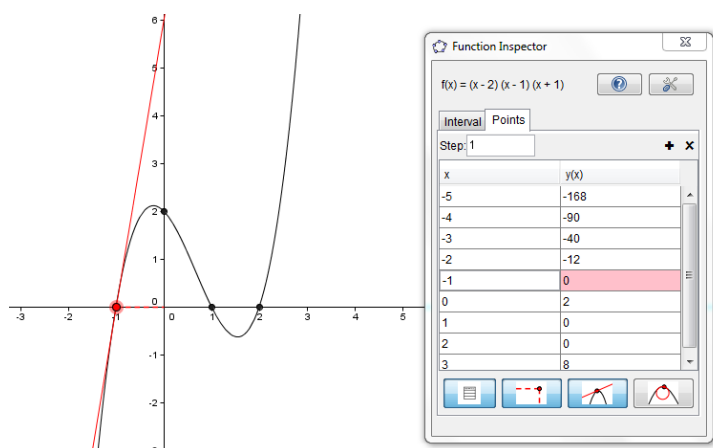
16. By clicking on the Show x, y position lines button tool you can show the $x\ y$ position of the point highlighted in the table.
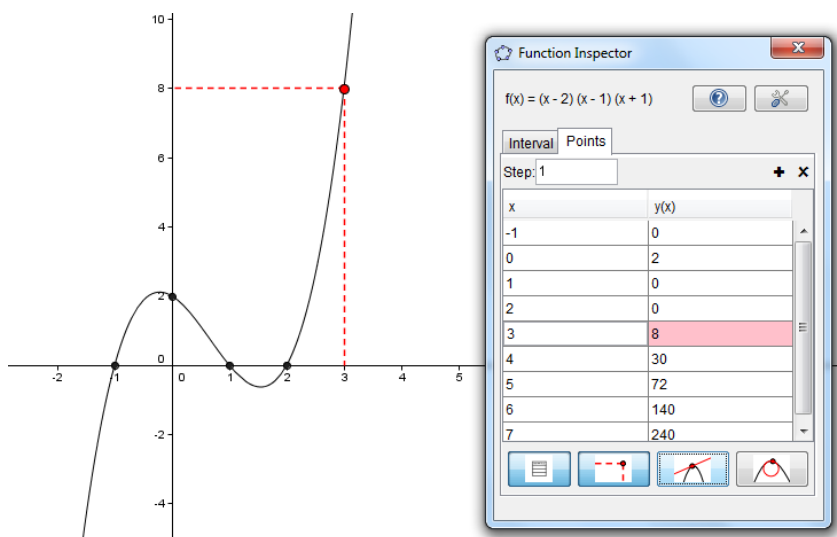
17. To add the derivative, second derivative, difference or curvature to the table click on

the ➕ button and choose Derivative, 2nd Derivative, Difference or Curvature.
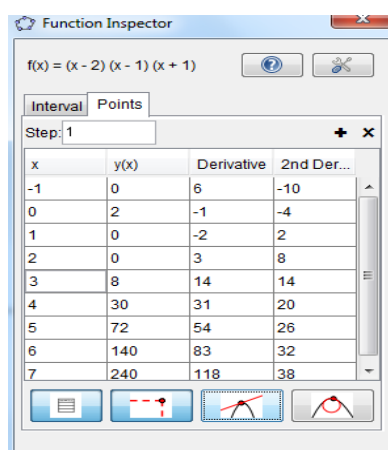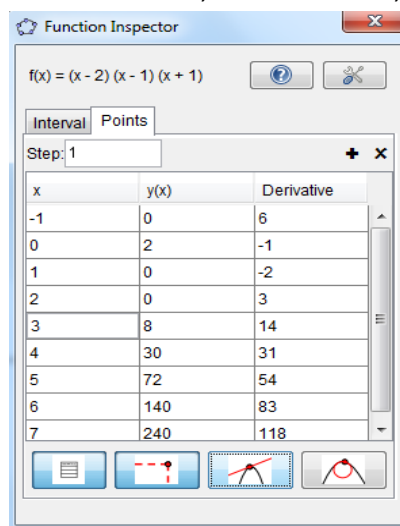
18. To remove the right column on the table click on the ☒ button.

19. To add other columns to the table re-click the ➕ button as often as required.

N.B. Work done using the Function Inspector cannot be saved, it must be done in class.

Activity 16: <u>The demonstrate the derivative of a quadratic is linear using the Function Inspector tool</u>

1. Go to File and New window to start a new file.

2. Select the Slider tool .
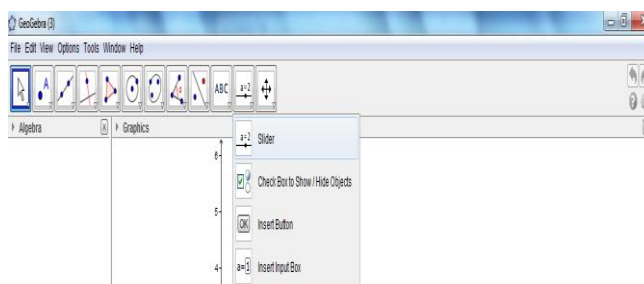
3. Click on the screen and a new window appears.
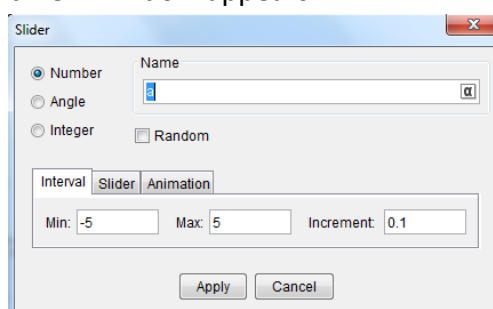
4. Change the Min to -10, Max to 10 and Increment to 1. Click Apply. This creates a slider called a.

5. Repeat steps 2, 3 and 4 above to make a slider called b, with the Min equal to -10, Max equal to 10 and Increment equal to 1.

6. Repeat steps 2, 3 and 4 above to make a slider called c, with the Min equal to -10, Max equal to 10 and Increment equal to 1.

7. In the Input Bar type f(x)=a x^2+b x+c and press Enter on the keyboard. Note the space between the a and the x and the b and the x.

8. In the Input Bar type f'(x). This will enable the first derivative of the function f(x) to appear on screen. (Provided your original function is called f.)

9. Go to Function Inspector and click on the derivative of the function.

10. Open the Points tab and click on the Show table of Points button .
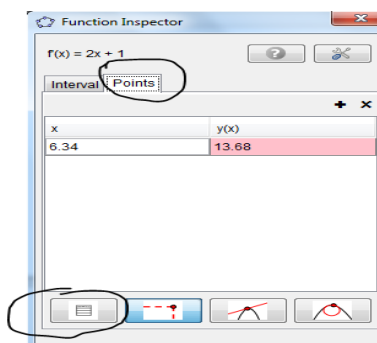
11. Click on the + button and choose Difference. Notice the values for the differences are all the same.
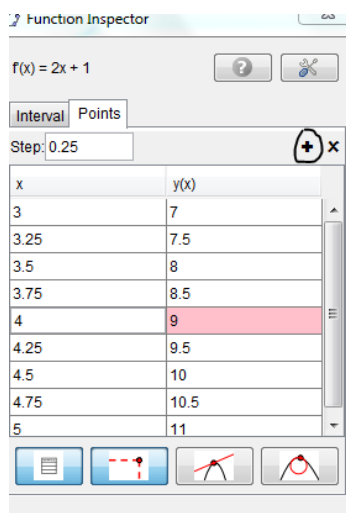

12. Move the sliders and while the values for the Difference changes depending on the values of your sliders you will notice the values for the Difference all stay the same for all values of x for a particular set of values for the sliders.
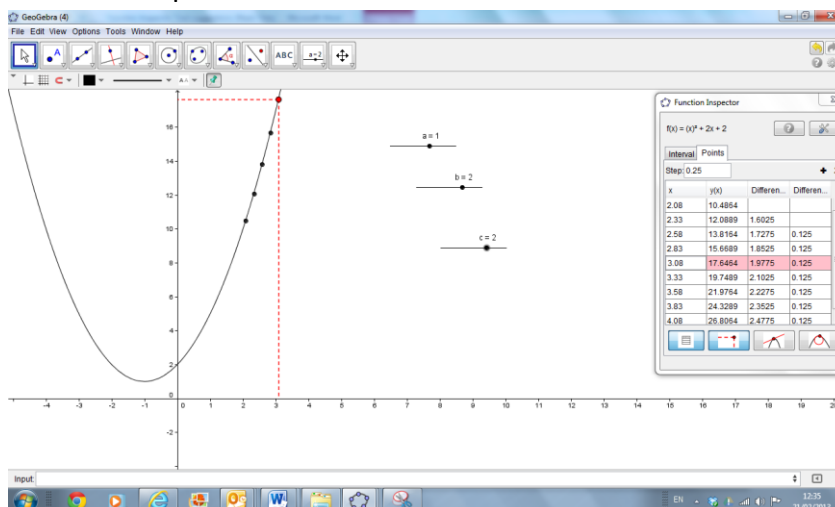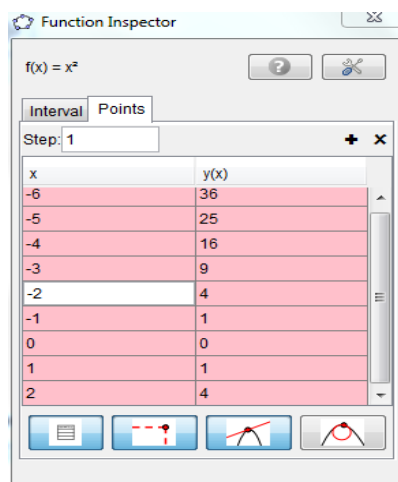
Activity 17: <u>To transfer points from the Function Inspector to the Spreadsheet View</u>

1. If the Spreadsheet View is not already in view, go to View and choose Spreadsheet.
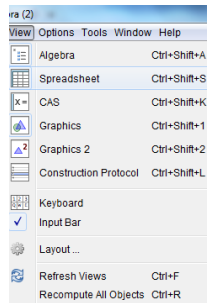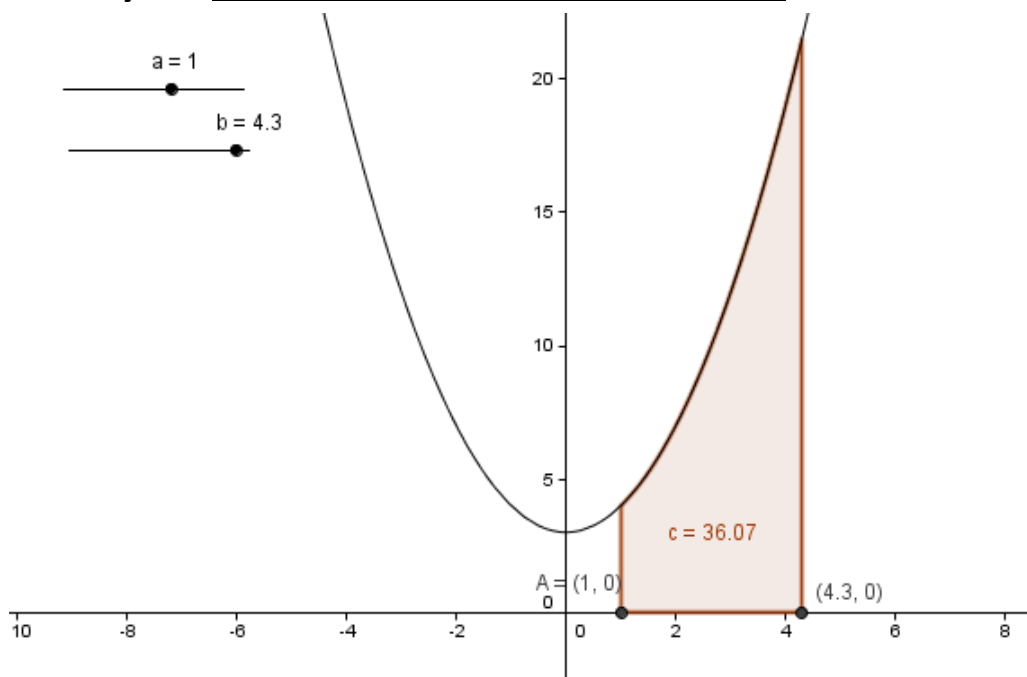

2. Highlight the data in the Function Inspector by dragging the cursor over them. Press Control and C on your keyboard.

3. Click on the Spreadsheet where you wish to insert the data and press Control and V on your keyboard.
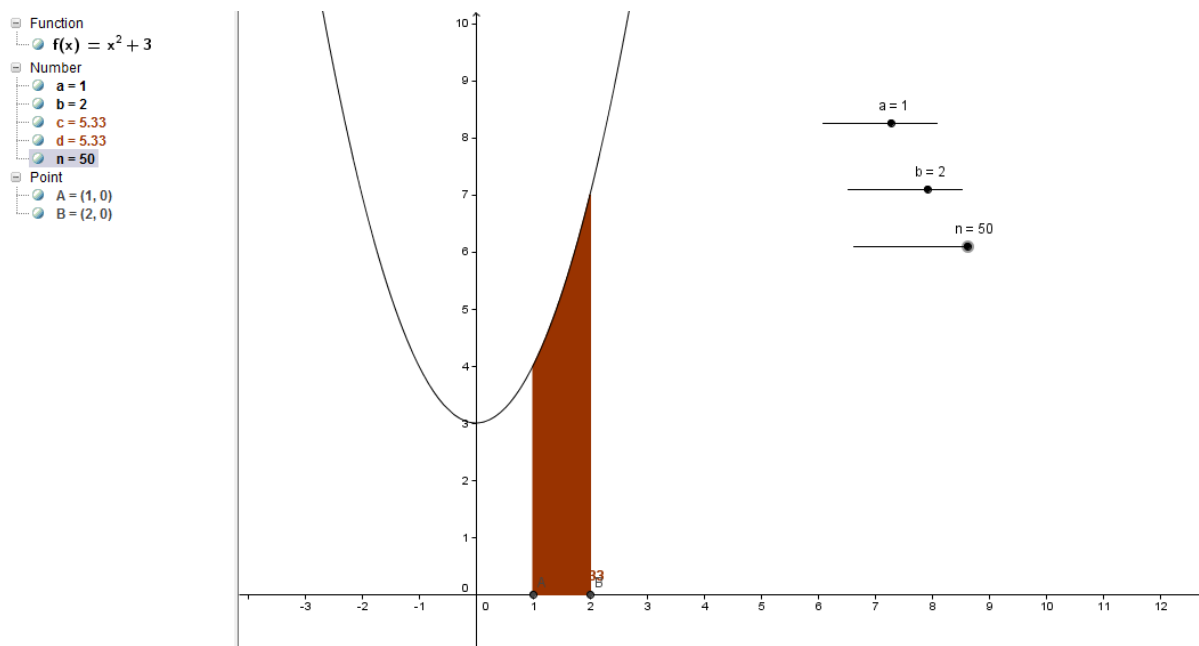
Activity 18: To demonstrate integration and area

1. Go to File and choose New Window.
2. By typing f(x)=x^2+3 draw the function $f(x) = x^2+3$.
3. Select the Slider tool ⬚. Click on the Graphics View and create a slider called a.
4. Select the Slider tool ⬚. Click on the Graphics View and create a slider called b.
5. Move the slider b to a value greater than the value of the slider a.
6. In the Input Bar type (a, 0) and press return. The point A(a,0) will now be marked on the diagram.
7. In the Input Bar type (b, 0) and press return. The point B(b,0) will now be marked on the diagram.
8. In the Input Bar choose the command Integral from the drop down menu at the extreme right of the Input Bar and inside the brackets type f,x(A),x(B).

   Input: Integral[f,x(A),x(B)]

   Note: x(A) takes the x value of the point A.
9. Move the points A and B to see how the area c changes.

## **Activity 19**: <u>**Integration and the Trapezoidal Rule**</u>

1. Go to File and choose New Window.
2. Create and find the integral of the function as in the activity above. (If you still have the last activity you can use it.)
3. Select the Slider tool ![a=2]. Click on the Graphics View and create a slider called n with min:=1, max: =50 and Increment:= 1.
4. In the Input Bar type b= TrapeziumSum[f,x(A),x(B),n].
5. Move the slider n and as n gets larger check the relationship between c (Area got by Integration) and d (Area got by Trapezoidal Rule).

Note: In this example the value for the Trapezoidal area between A and B when n = 50will appear to have the same value as c, the integral value between A and B because the numbers are rounded to two decimal places.

Activity 20: <u>**To find the area between the graph of a function and the x axis, where there is a section below and a section above the x axis**</u>
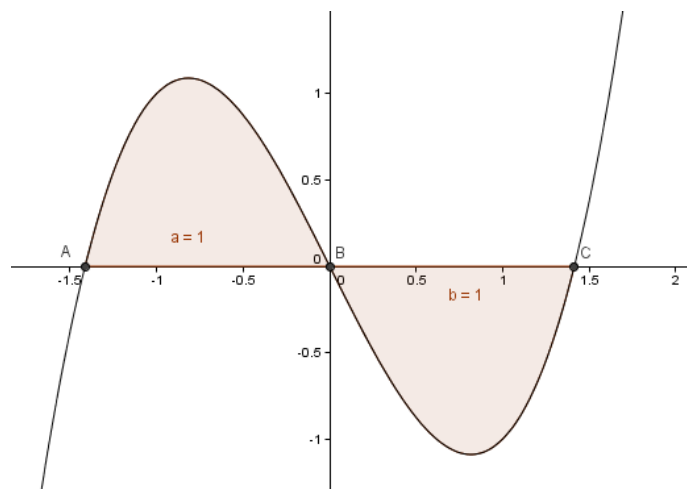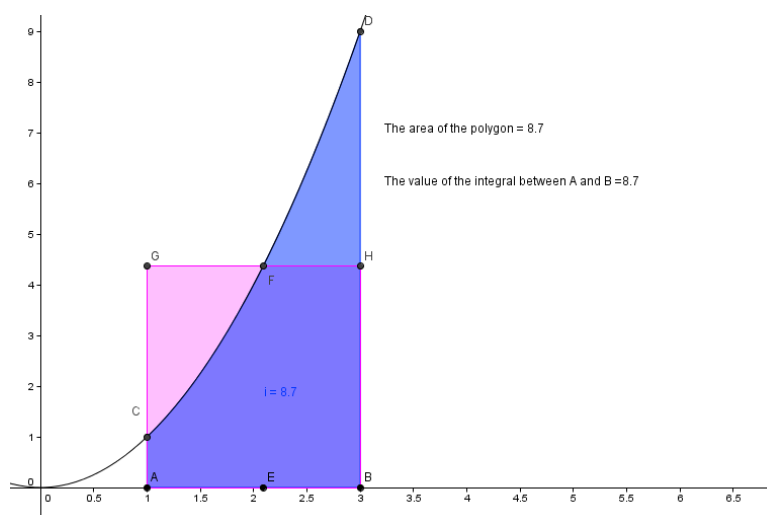

1. Go to File and choose New Window.
2. Draw a graph of a function for example f(x) = x³-x by typing f(x)=x^3-x in the Input Bar.
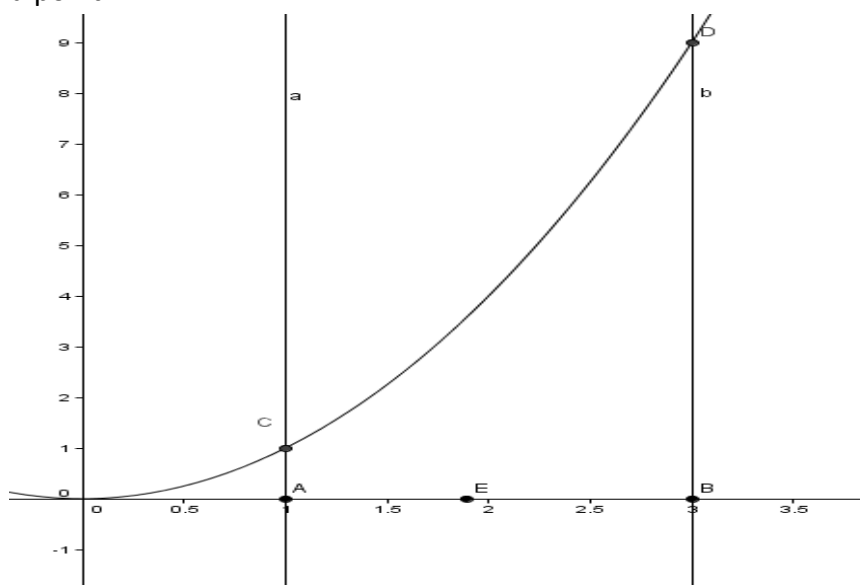3. Select the Intersect Two Objects tool [tool icon]. Click on the graph of the function and the x axis to find the points of intersection A, B and C of the graph of the function and the x axis.
4. In the Input Bar type a=Integral[f,x(A),x(B)].
5. In the Input Bar type b=Integral[f,x(C),x(B)]. Note. The order of A, B and C.
6. In the Input Bar type t=a+b to get the total area between the graph of the function and the x axis.

Activity 21: <u>**To demonstrate the average value of a function between 2 points**</u>

(For example f(x) = x^2 between x=1 and x = 3)

1. Go to File and choose New Window.
2. By typing f(x)=x^2 in the Input Bar, draw a graph of a function for example f(x) = x^2.
3. Select the Move tool ⊕ . Click on the x axis and drag to the right to extend the x axis.
4. Create point A at (1,0) and point B at (3,0).

5. Select the Perpendicular Line tool. Click on point A and the x axis to draw a line *a* perpendicular to the x axis at A.

6. Select the Perpendicular Line tool. Click on point B and the x axis to draw a line *b* perpendicular to the x axis at B.

7. Select the Intersect Two Objects tool. Click on the line a and the function f to find the point of intersection C of the line a and the function f.

8. Select the Intersect Two Objects tool. Click on the line b and the function f to find the point of intersection D of the line b and the function f.

9. Select the Point on Object tool. Click on the x axis between the points A and B to create a point E.

10. Select the Perpendicular Line tool. Click on the x axis and the point E to draw a line *c* perpendicular to the x axis at the point E.

11. Select the Intersect Two Objects tool [icon]. Click on the line c and the function f to find the point of intersection F of line c and the function f.

12. Select the Parallel Line tool [icon]. Click on the point F and the x axis to draw a line d through the point F parallel to the x axis.

13. Select the Intersect Two Objects tool [icon]. Click on the line d and the line a to find the point of intersection G of the line d and the line a.

14. Select the Intersect Two Objects tool [icon]. Click on the line d and the line b to find the point of intersection H of the line d and the line b.
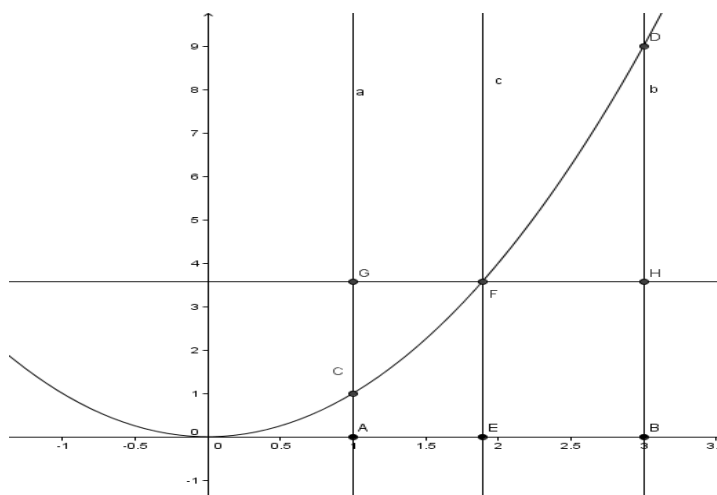

15. Right click on the lines a, b, c and d and deselect Show Object.

16. Select the Polygon tool [icon]. Click on the points A, B, H, G and A to draw the polygon ABHG.

17. Right click on the polygon ABHG, choose Object Properties and with the Colour tab open choose a bright pink colour and with the Colour tab open choose an Opacity of 50.

18. In the Input Bar type i= Integral[f,x(A),x(B)]. This will return the value of the area between the graph of the function and the x axis in the interval x=1 to x=3.

[image: Input: i=Integral[f,x(A),x(B)]]
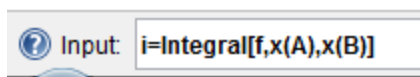
19. Right click the Integral in the Algebra View and with the Colour tab open choose a bright blue and Opacity of 50.

20. Move the point E along the x axis until the area of the polygon ABHG is equal to the value of the Integral i. At this point the area of the pink section of the polygon will equal the area of the blue section on the diagram. Hence the y value of point F is the average value of the function between A and B.
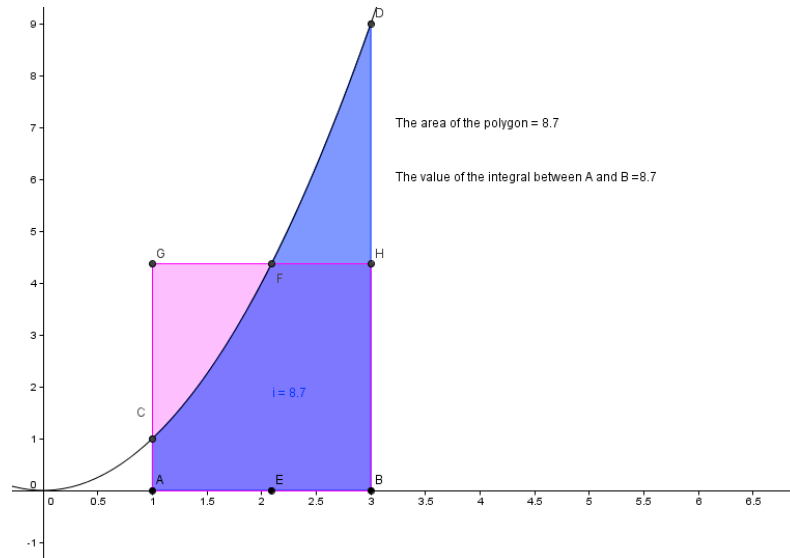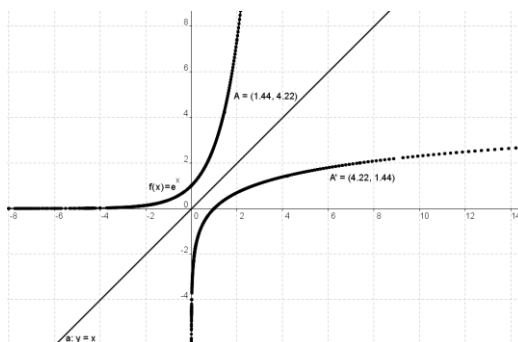
21. Checkboxes to Show / Hide Objects and Text boxes may be added.

## **Activity 22**: <u>**To draw the absolute value function**</u>

$$f(x) = |x - 3|$$
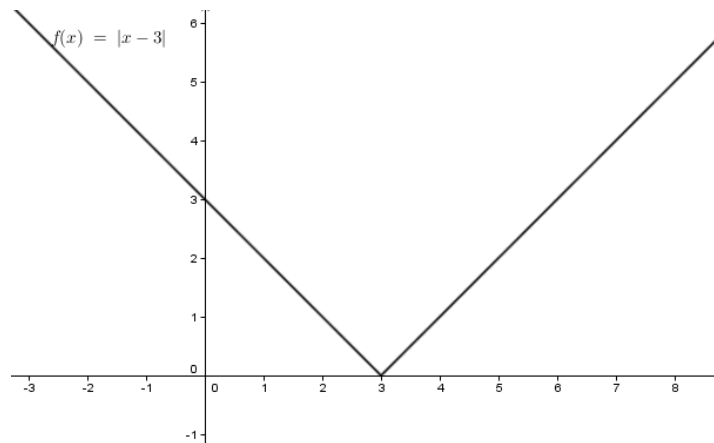
1. Go to File and choose New Window.
2. In the Input Bar type for example f(x)=abs(x-3) to draw the absolute value of the function x-3.

Activity 23: To draw e^x, ln(x) and look at the (inverse) relationship between them

1. Go to File and choose New Window.
2. In the Input Bar type f(x)=exp(x)
3. In the Input Bar type g(x)=ln(x)
4. In the Input Bar type y=x
5. Select the Check box to Show / Hide Objects tool [icon]. Insert the caption ln(x) and in the drop down menu under Select objects in construction or choose from list choose the function g.
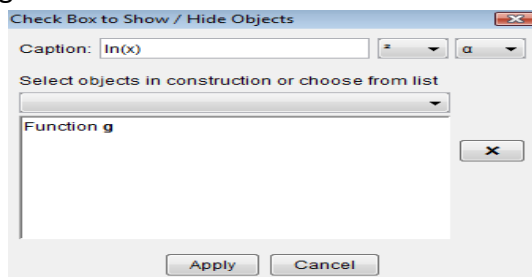
6. Select the Point on Object tool [icon]. Click on the exp(x) function to create a point A on it.

7. Select the Reflect Object in Line tool [icon]. Click on the point A and then the line y=x to reflect the point A in the line y=x. This creates a point A'.
   Note: Reflecting in the line y = x produces the inverse function.

8. Right click on A' and click Trace On.
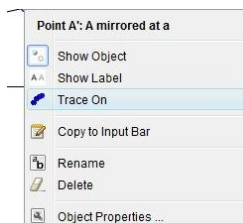
9. Select the Move tool [icon]. Click on the point A and move it along the graph of the function f(x) = exp(x) (slowly is best). A' should trace out a path.

10. Click the checkbox you created earlier and compare the path of A' to the ln(x) function.

Note: Clicking View in the Menu and Refresh Views from the drop down menu will clear the trace. Ctrl+F also works to clear the trace.

Activity 24: <u>To change the x axis to radian measure and draw a trigonometric function</u>

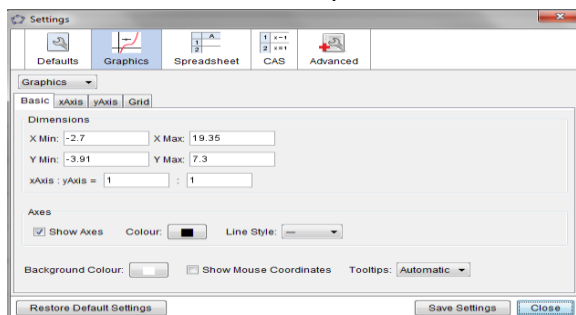1. Right click on the Graphics View and choose Graphics.
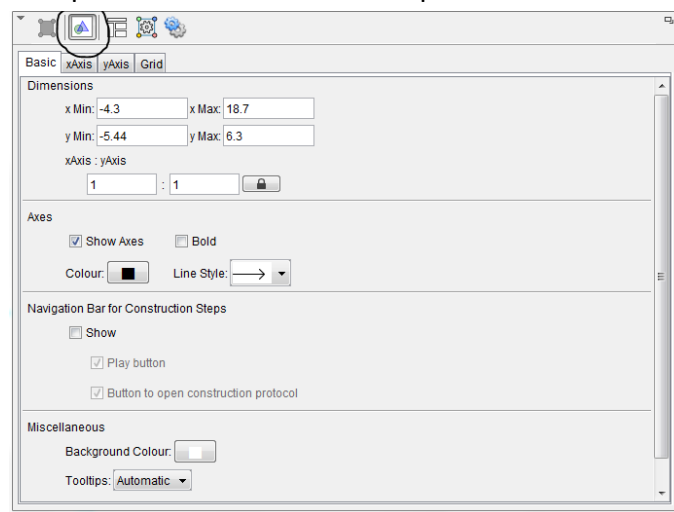
2. With the Preferences – Graphics button clicked, Click on the xAxis tab of the new dialogue box.

3. Click the arrow beside the Distance box and in the drop down menu beside Distance choose π or π/2. Click Close.
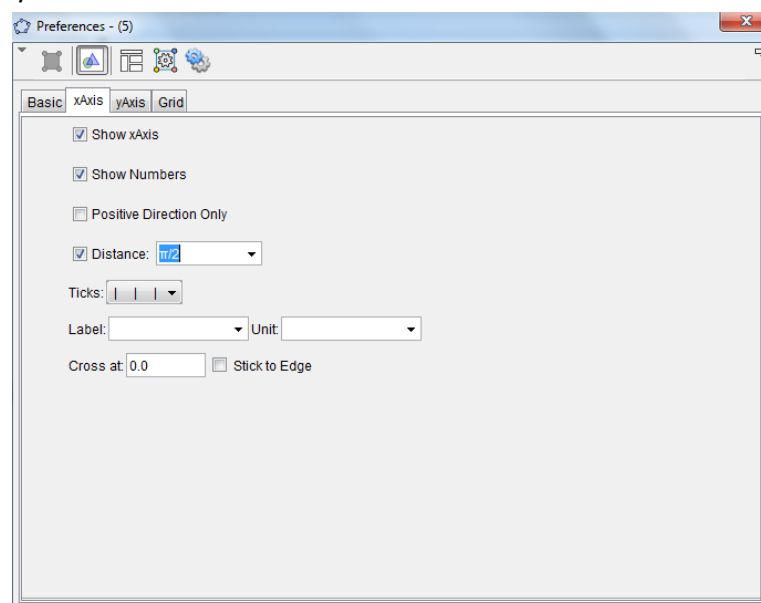
4. In the Input bar type for example **Input: f(x)=sin(x)** and press Enter on the keyboard.

Activity 25: <u>To change the x axis to degree measure and draw a trigonometric function</u>

1. Right click on the Graphics View and choose Graphics.

2. With the Preferences – Graphics button clicked, click on the x Axis tab of the new dialogue box.

3. Click the Distance box if not already clicked and type for example 10 if you want it to go up in tens. Using the drop down menu beside Unit choose the degree symbol. Click the X at the top of the dialogue box.
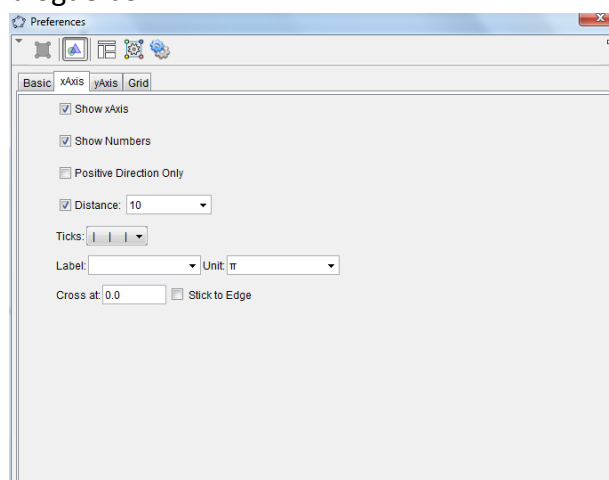
4. In the Input Bar type **Input: f(x)=sin(x°)**. Click on the α at the right hand side of the Input Bar to get the degree sign.

5. If necessary use the Move Graphics tool to decrease the scale of the x axis.
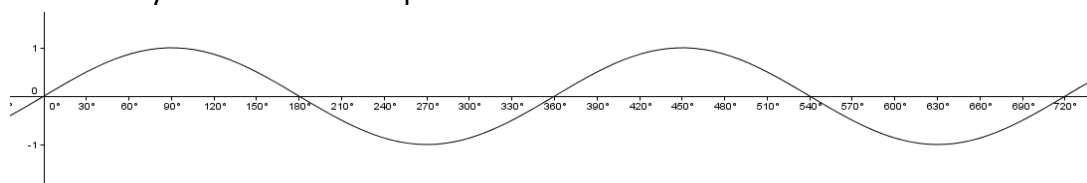
Activity 26: <u>To plot data in the Spreadsheet View in the Graphics View</u>

1. Highlight two columns of data in the Spreadsheet, right click, chose Create and List of points.
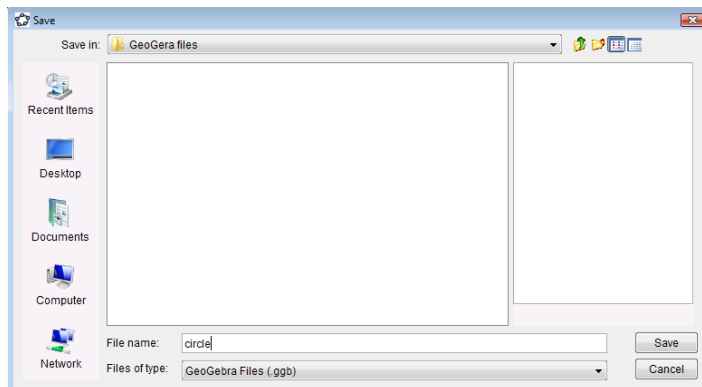
Activity 27: <u>To fit a graph to a list of points that are shown on the Graphics View</u>

1. In the Input Bar type Fitpoly[list1,2], if the list is list1 and you require a curve of degree 2 for example.

Appendix A

## A1: How to save a file as a GeoGebra file

1. Go to the Menu and choose Save as from the drop down menu. A new dialogue box appears.


2. For Save in, navigate to the folder that you wish the file to be saved in.

3. For File name type the name you wish to give your file.

4. Click Save. A file with the .ggb extension is created. This extension identifies the file as a GeoGebra file and it can be opened again and adjustments made using the GeoGebra application.

## A2: How to save a file as an interactive web page

1. First save your file as a GeoGebra file.
2. Go to File, from the drop down menu select Export and from the further menu select the option Export Dynamic Worksheet as Webpage (html). A new dialogue box appears.
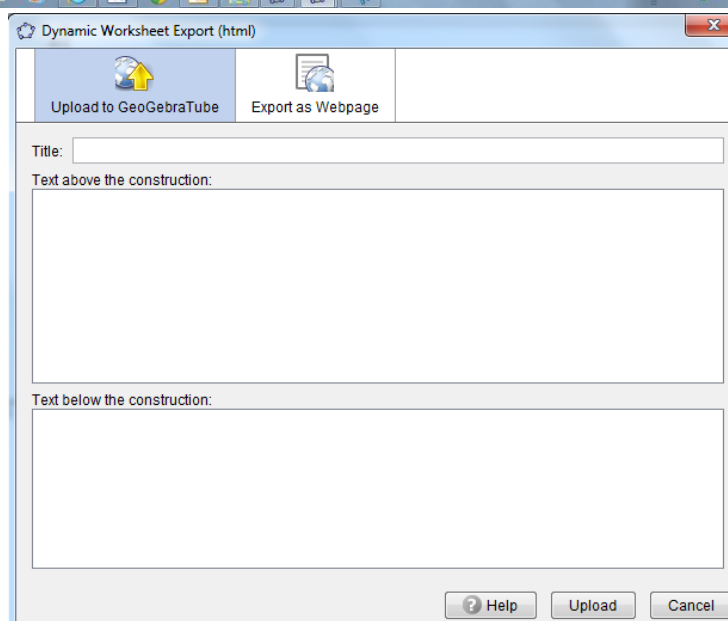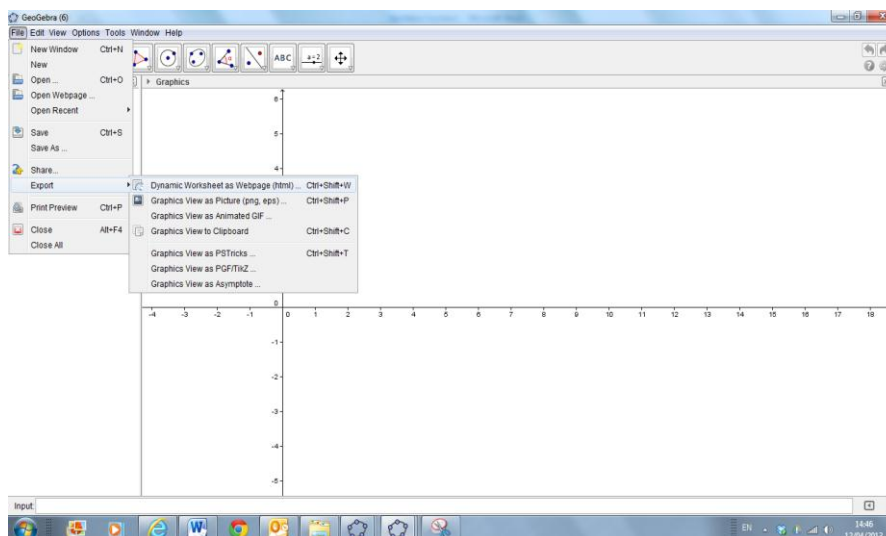
3. Click on the Export as Webpage tab.
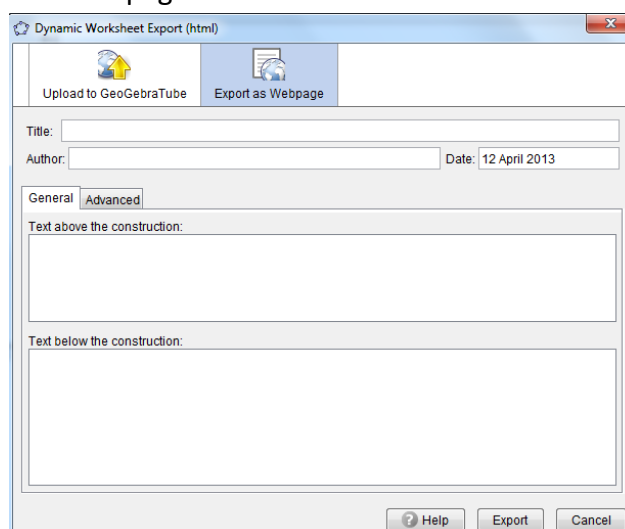
4. Add Title, Author, etc. Then click on the Advanced tab and a new dialogue box appears.
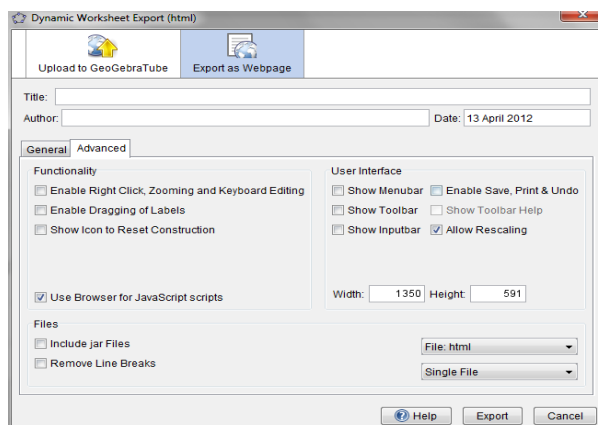
It is recommended that one clicks the Show Icon to reset construction button.

5. Click Export.
6. Navigate to the folder you want to save your file in. Give it the name of your choice. Note: This file will have a .html extension and will be viewed using an Internet browser such as Internet Explorer 8.
7. Click Save and your default Internet browser will open.
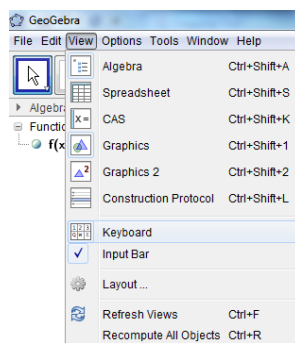8. When the webpage comes up you the following message will normally appear at the top of the screen.
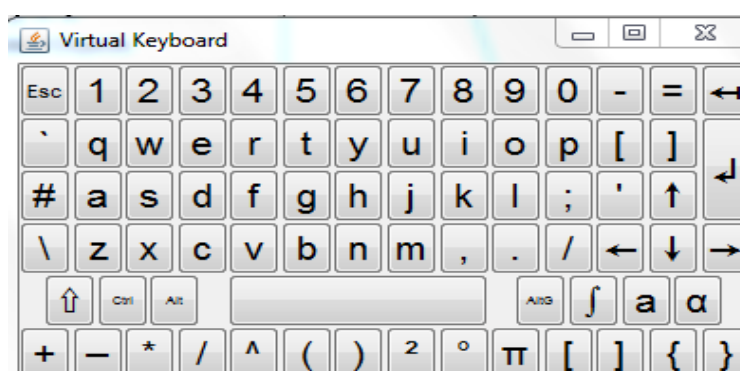

9. Click Allow Blocked Content.

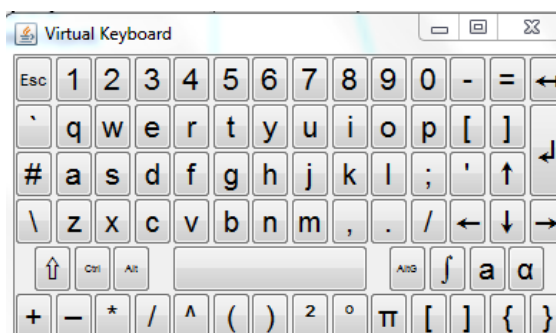## Appendix B: How to use the Virtual Keyboard in GeoGebra

1. Go to View and choose Keyboard.

2. A virtual keyboard appears.

3. If the keyboard below does not appear click on the ⊞ key on the virtual keyboard that appeared.

4. Then click on the ∫ key on the virtual keyboard to get the Maths keyboard.