

# GeoGebra 4

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Calculus – Integration

# Approximating the area under a curve with rectangles

## Setting up the graph


- Open a new file and create an Integer Slider control named  $n$ . From the Slider Properties allow:
  - $n$  to vary between 1 and 100 with a step-size increment of 1
- Type the following equation into the Input Bar and press the <RETURN> or <ENTER> key.

$$f(x) = \frac{\cos(2x)}{2} - \frac{x^2}{10} + 4$$

- Click on the Point Icon  and with the mouse pointer on top of the x-axis click twice to fix two points, A and B, to the axis (after first selecting the Point Tool and then moving the mouse anywhere on the screen, the mouse pointer should be a cross but once you position it over the x-axis then it will change in to the familiar pointer shape. This indicates that on clicking you will create a point constrained to move along the axis rather than it being a completely unconstrained point). Once done move the points so that point A is to the left of point B on the x-axis.
- In the Input Bar type the following: `LSum = LowerSum[f, x(A), x(B), n]`

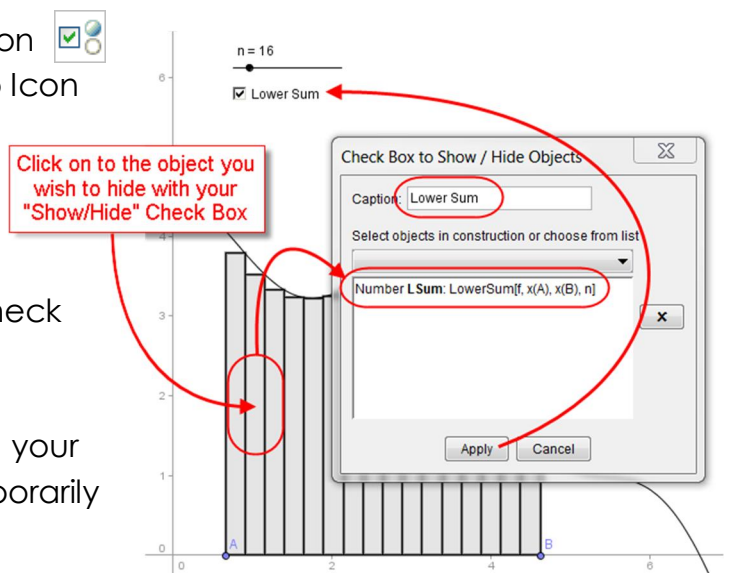
Here, we are giving the name "LSum" to the GeoGebra function LowerSum which automatically constructs  $n$  rectangles that touch the curve. What do you observe about how these rectangles touch the curve  $y = f(x)$ ? Do your observations explain why GeoGebra names this particularly useful function LowerSum?

Alter the value of  $n$  using its Slider control to see what happens. Move points A and B too to see their effect.

- Click on the 'Show/Hide' Check Box Icon  that appears within the 11<sup>th</sup> Tool Group Icon

We wish to allow our Lower-Sum rectangle to be hidden, if required. Therefore, follow the steps shown here to the right to create a 'Show/Hide' Check Box.

- Before the next step, remove the tick in your Check Box to hide the rectangles temporarily from view.



- Next, in the Input Bar type the following:  $USum = UpperSum[f, x(A), x(B), n]$

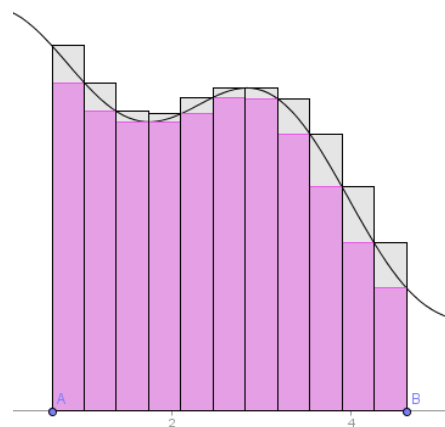
Here, we are giving the name "USum" to the GeoGebra function UpperSum which automatically constructs  $n$  rectangles having their upper right corners all touching our curve  $y = f(x)$

What observations can you make now?

- Create a second 'Show/Hide' Check Box named "Upper Sum" to hide the rectangles created by the UpperSum function.


You may notice that, with the colours selected automatically by GeoGebra, when the two sets of rectangles are visible at once that there is little to distinguish them. You may wish to modify them through the use of colour. I suggest that you first hide the UpperSum rectangles then Right-click on the LowerSum rectangles and from its properties alter the colour from the 'Colour' Tab and also alter the opacity of your chosen colour from the 'Style' Tab using the 'Opacity' Slider provided.

Here is an example of colouring that distinguishes clearly the two sets of rectangles when both visible.



Next we will now show the values, and the difference of these rectangle-area sums on the screen through the use of the 'Insert Text' Tool.

- Firstly, in the Input Bar, type:  $Diff = USum - Lsum$ . This needs to be done so that when we do wish to use dynamic text on the screen we have a value to select!

- From the 10<sup>th</sup> Tool Group Icon select the 'Insert text' icon . Clicking on the Graphics window where you want the text to go will open up the 'Insert Text' dialogue box. Follow the instructions shown here to create dynamic text for the area value of the 'LowerSum' rectangles:

- Repeat to place dynamic text values in the Graphics Window for the 'UpperSum' and 'diff' objects.

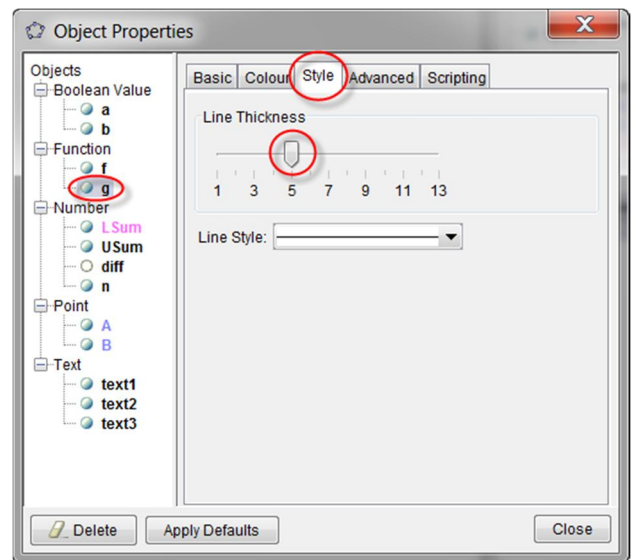
Only objects already defined, such as "diff", will be available to use as dynamic variables in text on screen

Manually type this part

As a final touch, and to demonstrate how to restrict the plotted range of a function, type the following in the Input Bar:

$$g(x) = \text{Function}[f, x(A) - 0.2, x(B) + 0.2]$$

Next, Right-click on f(x) in the Algebra View and from within its properties under the 'Style' Tab set its width to 1, whilst the Object Properties dialogue box is still open click on 'g' in its Objects window. Change g's width to 5.



You should now have a picture something like this below:

