

# Chapter 10 / Example 19

## Exploring the concavity of a function

For the function  $f(x) = x^4 - 3x^2 + 2$

- a** find the local maximum and minimum points, justifying the nature of each
- b** find the interval in which the curve is concave down.

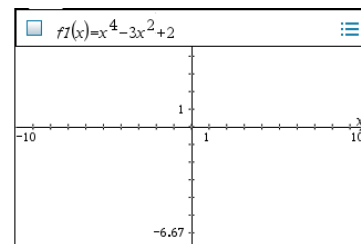
Open a new document and add a Graphs page.

The entry line is displayed at the top of the work area.

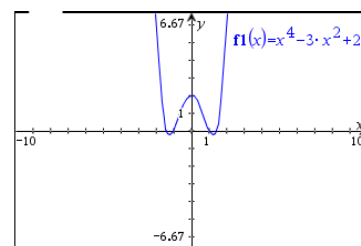
The default graph type is function, so 'f1(x)= ' is displayed.

The default axes are  $-10 \leq x \leq 10$  and  $-6.67 \leq y \leq 6.67$ .

Type  $x^4 - 3x^2 + 2$  and press **enter**.



The GDC displays the graph  $f1(x) = x^4 - 3x^2 + 2$  with the default axes.

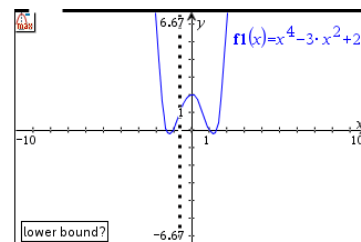


To find the maximum press **menu** 6:Analyse Graph | 3:Maximum

You will need to give the lower and upper bounds of the region that includes the maximum.

The GDC shows a line and asks you to set the lower bound. Move the line using the touchpad and choose a position to the left of the maximum.

Click the touchpad.

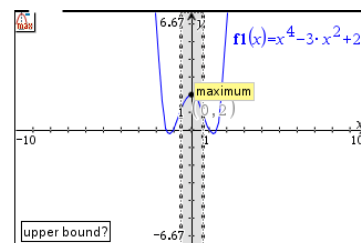


The GDC shows another line and asks you to set the upper bound.

Use the touchpad to move the line so that the region between the lower and upper bounds contains the maximum.

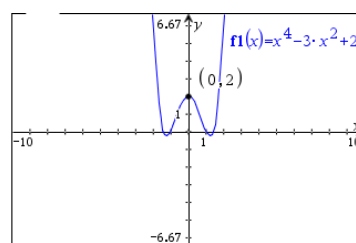
When the region contains the maximum, the calculator will display the word 'maximum' in a box.

Click the touchpad.



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The GDC displays the local maximum point at  $(0, 2)$ .

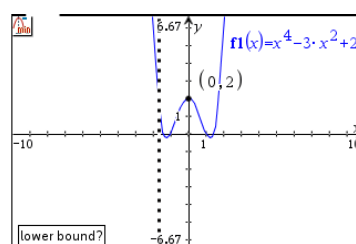


To find the minimum press **menu** 6:Analyse Graph | 2: Minimum

You will need to give the lower and upper bounds of the region that includes the minimum.

The GDC shows a line and asks you to set the lower bound. Move the line using the touchpad and choose a position to the left of the minimum.

Click the touchpad.

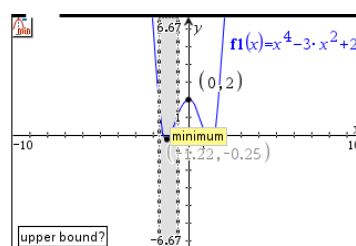


The GDC shows another line and asks you to set the upper bound.

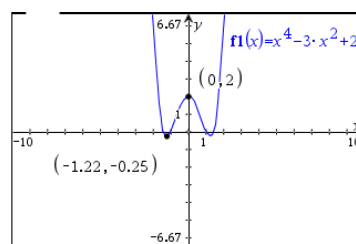
Use the touchpad to move the line so that the region between the lower and upper bounds contains the minimum.

When the region contains the minimum, the calculator will display the word 'minimum' in a box.

Click the touchpad.

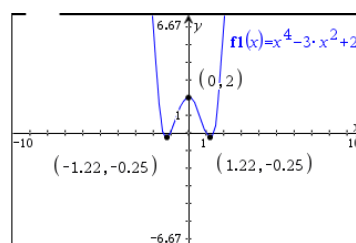


The first minimum point is at  $(-1.22, -0.25)$ .



Repeat for the second minimum.

The GDC displays a minimum at  $(1.22, -0.25)$ .



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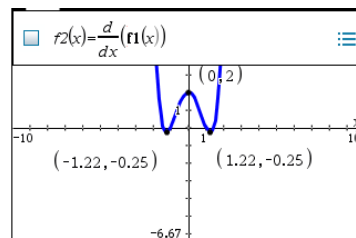
To find the point at which the concavity changes directly from a GDC you need to find where the second derivative is zero. A faster method is to find the stationary points of the first derivative.

To display the graph of the derivative press **tab** to display the entry line again. This time ' $f2(x)=$ ' is displayed.

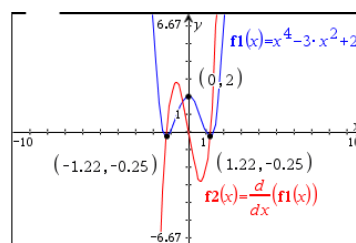
Press **2nd** and select  $\frac{d}{dx}$ .

Type X in the denominator and type the function  $f1(x)$

Press **enter**.



The GDC displays the graphs  $f1(x)$  and its first derivative.



Find the maximum and minimum points of the first derivative as before.

The points are  $-0.707, 2.83$  and  $0.707, -2.83$ .

The curve is concave down for  $-0.707 < x < 0.707$ .

