First Derivative Test … Set 1

Local Max & Mins & Inflection Points

For $f(x) = 2x^3 - 3x^2 - 12x$, determine:

a) Critical values.
b) Critical points.
c) Intervals on the x-axis where f(x) is increasing and decreasing.
d) Intervals on the x-axis where f(x) is concave up and concave down.
e) Determine point(s) of inflection, if any.
f) The relative maximum and relative minimum values of f(x).

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Answers

a) Critical values.

The critical values are found by setting $f'(x) = 0$ and solving for x.

Here $f'(x) = 6x^2 - 6x - 12$ then we need to solve $f'(x) = 6x^2 - 6x - 12 = 0$.

$6(x^2 - x - 2) = 6(x-2)(x+1) = 0 \quad \Rightarrow$ **$x = 2$ & $x = -1$ are the critical values.**

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Answers

b) Critical Points.

Critical points are points on the graph of the function, f(x). So we need to substitute -1 & 2 into f(x) to get the coordinates.

(2, -20) & (-1, 7) are the critical points.

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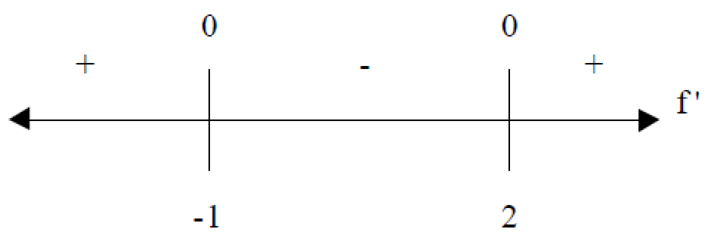
Answers

C) Intervals where f(x) is increasing and decreasing.

Recall, $f'(x) = 6x^2 - 6x - 12 = 6(x-2)(x+1)$, we will use the first derivative test here.



All we did here was select representative values from each interval and substitute into $f'(x)$. For example, for the first interval on the left pick $x = -2$, then $f'(-2) > 0$. So then the first derivative is positive for any x-value to the left of -1. Since the first derivative is positive, then the function is increasing for these x-values.

f(x) is increasing for: $(-\infty, -1) \cup (2, \infty)$

f(x) is decreasing for: $(-1, 2)$.

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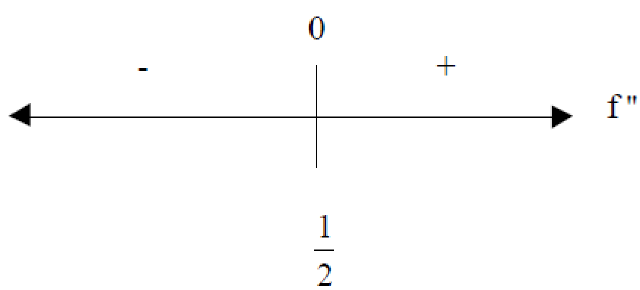
D) <u>Intervals where f(x) is concave up and concave down.</u>

To discuss concavity, you need the second derivative, $f''(x)$. Recall $f'(x) = 6x^2 - 6x - 12$.

So, $f''(x) = 12x - 6$. To get the intervals we need to set this equal to zero.

$f''(x) = 12x - 6 = 6(2x-1) = 0 \quad \Rightarrow \quad x = \frac{1}{2}$. Now let's mimic the first derivative test.



Here, we select any value to the left of 1/2, say $x = 0$ and plug into $f''(x)$.

$f''(0) < 0$ so $f''(x)$ will be negative for any value we pick that is less than 1/2.

f(x) is concave up for: $\left(\frac{1}{2}, \infty\right)$

f(x) is concave down for: $\left(-\infty, \frac{1}{2}\right)$.

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E) <u>Point(s) of inflection, if any.</u>

For a point of inflection to exist, **two** things must occur:

a) There must be some x-value, c, such that $f''(c) = 0$
b) The second derivative must change sign at this x-value, c.

Notice here that both (a) and (b) occur. For (a), $f''(1/2) = 0$ and $f''(x)$ changes from negative to positive as **x** passes through $\frac{1}{2}$.

Now be careful, we need the ***point*** of inflection that is we need a coordinate on f(x) where the function changes concavity.

Here $\left(\frac{1}{2}, -6.5\right)$ **is the *point* of inflection.**

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F) **The relative maximum and relative minimum values of f(x).**

To determine the relative maximum and relative minimum values of f(x) we need the Second Derivative Test.

Second Derivative Test:

a) if $f''(c) < 0$, then the critical point $(c, f(c))$ is a relative maximum.
b) if $f''(c) > 0$, then the critical point $(c, f(c))$ is a relative minimum.
c) if $f''(c) = 0$, then the test fails.

$f''(-1) < 0$, so $f(-1) = 7$ is a relative maximum value of f(x). Or, (-1, 7) is a relative maximum point on the graph of f(x).

$f''(2) > 0$, so $f(2) = -20$ is a relative minimum value of f(x). Or, (2, -20) is a relative minimum point on the graph of f(x).