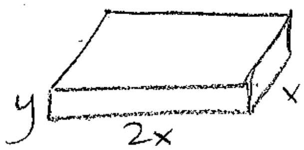
300 square inches of material is available to make a box with a rectangular base. The width of the base must be twice its length. The box must include a top.

SCORE: _____ / 30 PTS

<u>You must use calculus to solve the following problems.</u>

[a] What is the largest possible volume of the box ?



$x \geq 0$ AND $4x^2 \leq 300$

$x^2 \leq 75$

$x \leq 5\sqrt{3}$

MAXIMIZE $V = 2x^2 y$

$4x^2 + 6xy = 300$

$2x^2 + 3xy = 150$

$y = \dfrac{150 - 2x^2}{3x}$

$V = 2x^2\left(\dfrac{150 - 2x^2}{3\cancel{x}}\right) = \dfrac{300x - 4x^3}{3}$ ON $x \in [0, 5\sqrt{3}]$

$V' = \dfrac{300 - 12x^2}{3}$ IS DEFINED ON $[0, 5\sqrt{3}]$

$= 0$ @ $300 = 12x^2$

$25 = x^2$

$x = 5$

x	V
0	0
5	$\dfrac{1500 - 500}{3} = \dfrac{1000}{3}$
$5\sqrt{3}$	0

THE LARGEST VOLUME IS $\dfrac{1000}{3}$ CUBIC INCHES

[b] Find the dimensions of the box which give the largest possible volume.

BASE: $5'' \times 10''$

HEIGHT: $\dfrac{20}{3}''$

Find $\int \frac{(3x^4-2)^2}{5x^5}\,dx$.

SCORE: _____ / 15 PTS

$= \int \frac{9x^8-12x^4+4}{5x^5}\,dx$

$= \int \left(\frac{9}{5}x^3 - \frac{12}{5}x^{-1} + \frac{4}{5}x^{-5}\right)dx$

$= \frac{9}{5}\frac{1}{4}x^4 - \frac{12}{5}\ln|x| + \frac{4}{5}\left(-\frac{1}{4}\right)x^{-4} + C$

$= \frac{9}{20}x^4 - \frac{12}{5}\ln|x| - \frac{1}{5}x^{-4} + C$

Find $\lim_{x\to 0^+} \sqrt[3]{x}\ln x$. $\quad 0\cdot -\infty$

SCORE: _____ / 15 PTS

$= \lim_{x\to 0^+} \frac{\ln x}{x^{-\frac{1}{3}}} \qquad \frac{-\infty}{\infty}$

$= \lim_{x\to 0^+} \frac{\frac{1}{x}}{-\frac{1}{3}x^{-\frac{4}{3}}}$

$= \lim_{x\to 0^+} -3x^{\frac{1}{3}} = 0$

Does Rolle's Theorem apply to the function $f(x) = \sqrt[3]{x^2-8x+15}$ on the interval $[1, 7]$?

SCORE: _____ / 15 PTS

(That is, are all conditions of Rolle's Theorem true for $f(x) = \sqrt[3]{x^2-8x+15}$ on the interval $[1, 7]$?)
If yes, find the value of c guaranteed by Rolle's Theorem. If no, explain why not.

$f'(x) = \frac{1}{3}(x^2-8x+15)^{-\frac{2}{3}}(2x-8)$

IS UNDEFINED @ $x^2-8x+15=0$

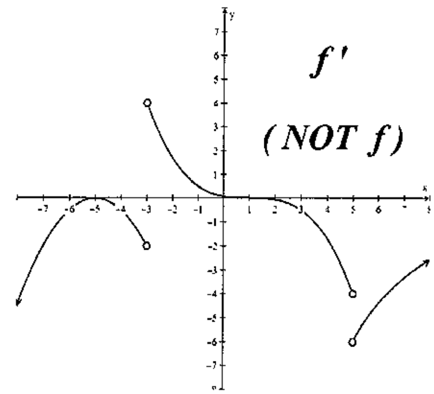
$(x-3)(x-5)=0$

$x=3,5 \in [1,7]$

f IS NOT DIFFERENTIABLE ON $[1,7]$
SO ROLLE'S THEOREM DOES NOT APPLY

$f(x)$ is a continuous function whose derivative $f'(x)$ is shown on the right. **SCORE: _____ / 24 PTS**

The following questions are about the function f, **<u>NOT THE FUNCTION f'</u>**.



[a] Find the $x-$coordinates of all inflection points of f.
<u>Justify your answer very briefly.</u>

f' CHANGES FROM INCR TO DECR : $X = -5$
DECR INCR $X = 5$

[b] Find the intervals over which f is increasing.
<u>Justify your answer very briefly.</u>

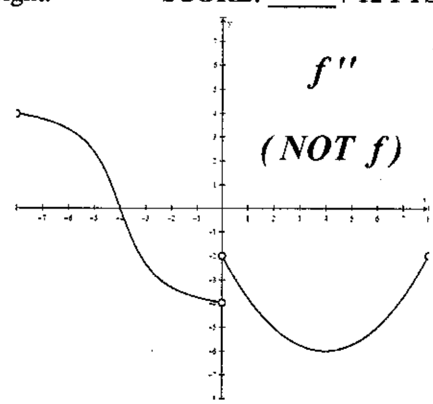
$f' > 0 : (-3, 1)$

[c] Find all critical numbers of f, and state what the First Derivative Test tells you about each one.
<u>Justify your answer very briefly.</u>

$f' = 0 : -5$ f' CHANGES FROM $-$ TO $-$ $\rightarrow$ NOT EXTREMA
1 $+$ $-$ $\rightarrow$ LOCAL MAX
f' DNE: -3 $-$ $+$ $\rightarrow$ LOCAL MIN
5 $-$ $-$ $\rightarrow$ NOT EXTREMA

$f(x)$ is a continuous and differentiable function whose second derivative $f''(x)$ is shown on the right. **SCORE: _____ / 12 PTS**

The following questions are about the function f, **<u>NOT THE FUNCTION f''</u>**.



[a] If $f'(-6) = 0$,
what does the Second Derivative Test tell you about the point $(-6, f(-6))$?
<u>Justify your answer very briefly.</u>

$f''(-6) > 0 \rightarrow$ LOCAL MIN

[b] Find the intervals over which f is concave up.
<u>Justify your answer very briefly.</u>

$f'' > 0 : (-8, -4)$

Graph $f(x)=\dfrac{x}{(4-x)^3}+2$ using the process shown in lecture and in the website handout. **SCORE: _____ / 40 PTS**

The first and second derivatives are $f'(x)=(4-x)^{-3}+3x(4-x)^{-4}$ and $f''(x)=6(4-x)^{-4}+12x(4-x)^{-5}$.

<u>Do NOT find x–intercepts.</u>
<u>Complete the table below, after showing relevant work (except for entries marked ★).</u>
<u>You will NOT receive credit for the entries in the table if the relevant work is missing.</u>

★ Domain	★ Discontinuities	y – intercepts **ONLY**	One sided limits at each discontinuity (write using proper limit notation)	
$x \neq 4$	$x = 4$	$(0,2)$	$\lim\limits_{x\to 4^+} f(x) = -\infty$	$\lim\limits_{x\to 4^-} f(x) = \infty$
Horizontal Asymptotes	Intervals of Increase	Intervals of Decrease	Intervals of Upward Concavity	Intervals of Downward Concavity
$y = 2$	$(-2,4)$, $(4,\infty)$	$(-\infty,-2)$	$(-4,4)$	$(-\infty,-4)$ $(4,\infty)$
Vertical Tangent Lines	Horizontal Tangent Lines	Local Maxima	Local Minima	Inflection Points
NONE	$x=-2$	NONE	$(-2, 1\frac{107}{108})$	$(-4, 1\frac{255}{256})$

$f(0) = \frac{0}{4^3}+2 = 2$

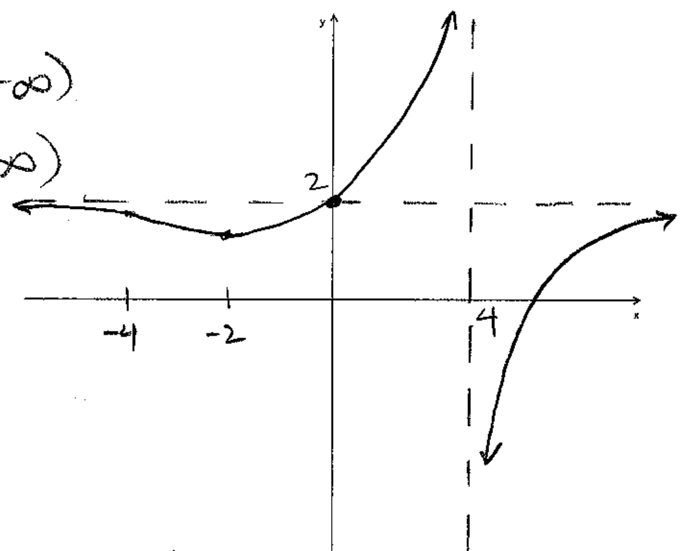
$\lim\limits_{x\to 4^+}\left(\frac{x}{(4-x)^3}+2\right) = -\infty \quad \left(\frac{4}{0^-}+2 \to -\infty+2 \to -\infty\right)$

$\lim\limits_{x\to 4^-}\left(\frac{x}{(4-x)^3}+2\right) = \infty \quad \left(\frac{4}{0^+}+2 \to \infty+2 \to \infty\right)$

$\lim\limits_{x\to \pm\infty}\left(\frac{x}{(4-x)^3}+2\right) = \left(\lim\limits_{x\to\pm\infty}\frac{1}{-3(4-x)^2}\right)+2$

$\frac{\infty}{\pm\infty}+2$

$= 0+2 = 2$



$f'(x) = (4-x)^{-4}(4-x+3x)$

$= (4-x)^{-4}(2x+4)$

$= 2(4-x)^{-4}(x+2)$ UNDEFINED @ $x=4 \notin$ DOMAIN

$= 0$ @ $x=-2$

$f''(x) = 6(4-x)^{-5}(4-x+2x)$

$= 6(4-x)^{-5}(x+4)$ UNDEFINED @ $x=4 \notin$ DOMAIN

$= 0$ @ $x=-4$

f'	$-$		$-$	LOCAL	$+$		$+$
f''	$-$	IP	$+$	MIN	$+$		$-$
		-4		-2		4	