APC SEMESTER 1 EXAM REVIEW

Calculator NOT Permitted UNIT 1

FREE RESPONSE

Consider the functions below to answer the following questions.

$$F(x) = \begin{cases} x^2 + 2|x|, & x < -2 \\ 3x + a, & x > -2 \end{cases} \qquad\qquad G(x) = \frac{2x^2-5x-3}{x^2-9}$$

a. Find the value of $\lim\limits_{x \to -2^-} F(x)$. Show your work.

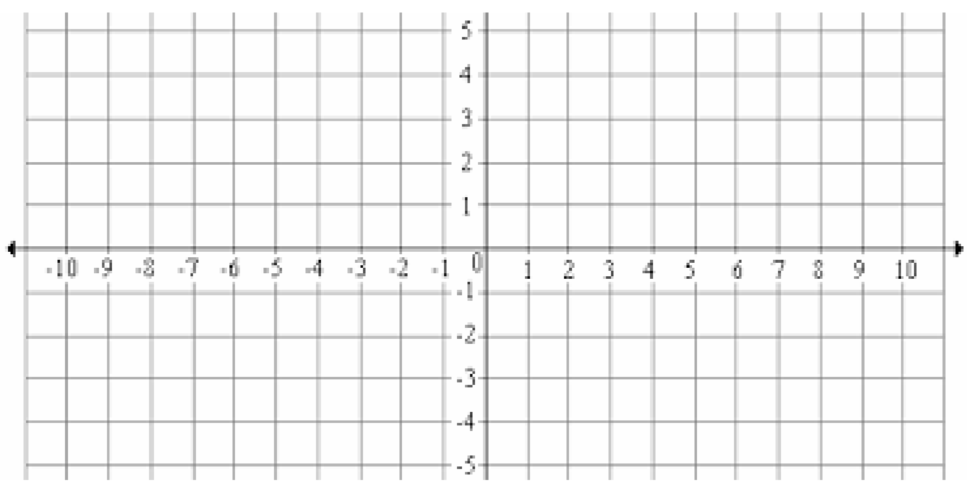
b. In order for $\lim\limits_{x \to -2} F(x)$ to exist, what two limits must be equal? Find the value(s) of *a* for which this limit exists. Show your work.

c. Find the value of $\lim_{x\to 3} G(x)$? Is $G(3) = \lim_{x\to 3} G(x)$? Explain why or why not. Show your work.

d. Draw a graph of a function, *H*(*x*), that meets the following criteria.

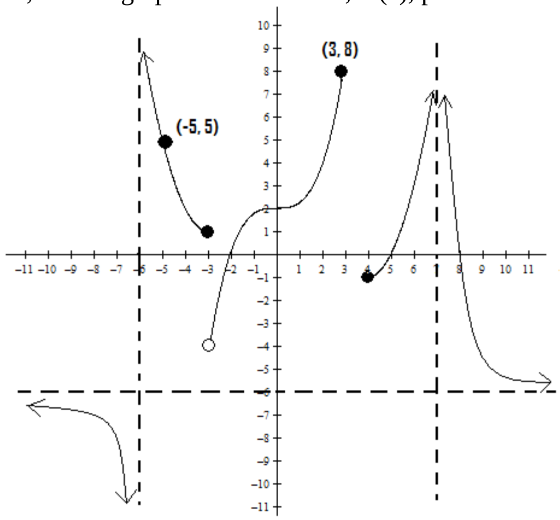
$\lim_{x\to -2^-} H(x) = \infty$ $\lim_{x\to -2^+} H(x) = -\infty$ $\lim_{x\to 2} H(x) = 3$

$\lim_{x\to -\infty} H(x) = 0$ $H(2) = -4$



MULTIPLE CHOICE

For questions 1 and 2, use the graph of the function, $H(x)$, pictured below.



1. Which of the following statements is/are true about the graph of $H(x)$?

I. $\lim_{x\to -3^+} H(x) = H(-3)$ II. $\lim_{x\to\infty} H(x) = -6$ III. $\lim_{x\to -6^-} H(x) = -\infty$

A. I and II only B. II only C. III only

D. II and III only E. I, II and III

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2. Which of the following limit(s) do(es) **not** exist?

I. $\lim_{x\to 7} H(x)$ II. $\lim_{x\to -3} H(x)$ III. $\lim_{x\to 0} H(x)$

A. I only B. I and II only C. II only

D. II and III only E. III only

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3. If $g(x) = \begin{cases} e^x(x+1), & x < -2 \\ cos(\pi x), & x > -2 \end{cases}$, which of the following statements is/are true?

I. $g(-2)$ is undefined. II. $\lim_{x\to -2^-} g(x) = -\frac{1}{e^2}$ III. $\lim_{x\to -2} g(x)$ exists.

A. I and II only B. II only C. II and III only

D. I and III only E. I, II, and III

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4. Find $\lim_{x\to\frac{\pi}{6}} \frac{\sin x}{3x}$.

A. $\frac{\sqrt{3}}{\pi}$ B. $-\frac{\sqrt{3}}{2\pi}$ C. $\frac{\sqrt{3}}{2\pi}$ D. $-\infty$ E. $\frac{1}{\pi}$

5. Find $\lim_{x \to 3} \frac{\sqrt{x+1}-2}{x-3}$.

A. 4 B. $\frac{1}{2}$ C. $\frac{1}{4}$

D. –4 E. Limit does not exist.

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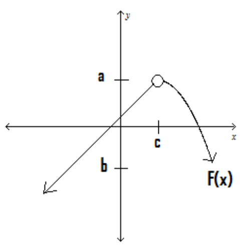
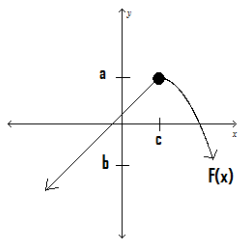
6. Which one of the following graphs shows that $F(c)$ is defined but the $\lim_{x \to c} F(x)$ does not exist?

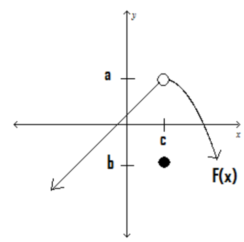
A.



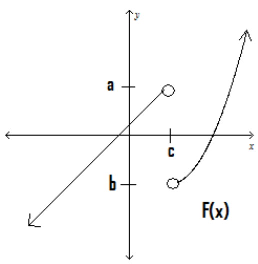
B.



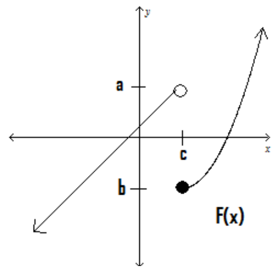
C.



D.



E.



7. Given the graph of a function *f*(*x*). The value of $\lim_{x \to 2} \sqrt{2f(x)}$ is…

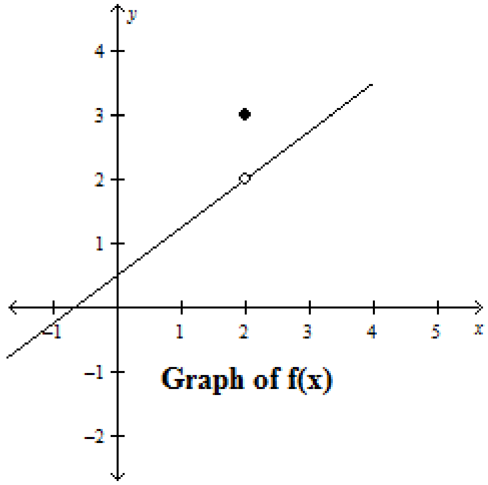
A. $\sqrt{3}$

B. $\sqrt{6}$

C. 2

D. $\sqrt{2}$

E. $2\sqrt{2}$



Multiple Choice

1. **D**
2. **B**
3. **A**
4. **E**
5. **C**
6. **E**
7. **C**

Free Response Part A – 1 point total

____ 1: $\lim_{x\to -2^-} F(x) = (-2)^2 + 2|-2| = 4 + 4 = 8$.

Free Response Part B – 2 points total

____ 1: $\lim_{x\to -2^-} F(x)$ must equal $\lim_{x\to -2^+} F(x)$ in order for $\lim_{x\to -2} F(x)$ to exist.

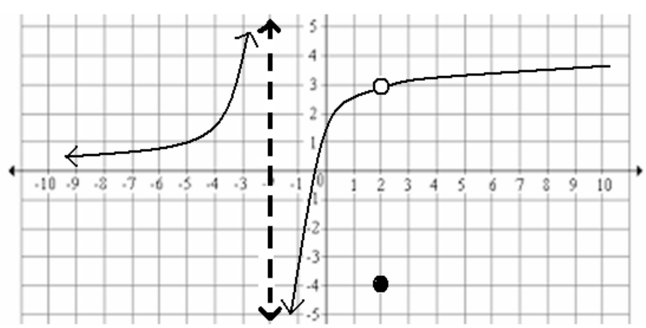
____ 1: $\lim_{x\to -2^-} F(x) = \lim_{x\to -2^+} F(x) \to 8 = 3(-2) + a \to a = 14$.

Free Response Part C – 2 points total

____ 1: $\lim_{x\to 3} \frac{(2x+1)(x-3)}{(x+3)(x-3)} = \lim_{x\to 3} \frac{2x+1}{x+3} = \frac{2(3)+1}{3+3} = \frac{7}{6}$

____ 1: Since $G(3)$ is undefined and $\lim_{x\to 3} G(x) = \frac{7}{6}$, then $G(3) \neq \lim_{x\to 3} G(x)$.

Free Response Part D – 4 points total



____ 1: Vertical asymptote at $x = -2$

____ 1: Removable discontinuity at the point (2, 3)

____ 1: Point located at (2, –4)

____ 1: Graph exhibits horizontally asymptotic behavior as $x \to -\infty$.

FREE RESPONSE

The derivative of a polynomial function, $f(x)$, is represented by the equation $f'(x) = -2x(x-3)^2$. Additionally, $f(2) = -3$ and the graph of $f(x)$ is concave up at $x = 2$. Use this information to answer the following questions.

a. At what value(s) of x does the graph of $f(x)$ have a relative maximum? A relative minimum? Show your sign analysis and use it to justify your reasoning.

b. On what interval(s) is the graph of $f(x)$ increasing? Decreasing? Justify your reasoning.

c. Using the equation of the tangent line drawn to $f(x)$ at $x = 2$, what is the tangent line approximation of $f(2.1)$? Is this estimate greater or less than the actual value of $f(2.1)$? Give a reason for your answer.

MULTIPLE CHOICE

1. If $g(x) = -3x^3 + 5x - 3$, then the slope of the normal line drawn to $g(x)$ at $x = 1$ would be…

   A. 4

   B. $\frac{1}{4}$

   C. –4

   D. $-\frac{1}{4}$

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2. The equation $x - \frac{1}{2} = -2(y + 4)$ represents the equation of the tangent line to the graph of $g(x)$ when $x = -1$. What is the value of $g'(-1)$?

   A. –½ B. –2

   C. 4 D. Cannot be determined.

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3. The normal line drawn to the graph of $g(x)$ at $x = 2$ is given by the equation $y = 3x - 2$. Which of the following conclusions can be made about $g(x)$?

   A. The graph of $g(x)$ is increasing at $x = 2$.
   B. The graph of $g(x)$ is decreasing at $x = 2$.
   C. The graph of $g(x)$ has a horizontal tangent at $x = 2$.
   D. None of these conclusions can be made about $g(x)$ at $x = 2$.

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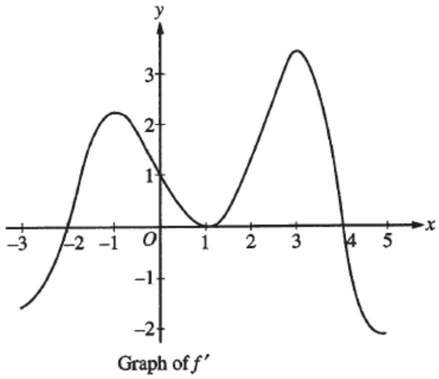
4. The graph of the <u>derivative</u> of a function f is shown to the right. The graph has horizontal tangent lines at $x = -1$, $x = 1$, and $x = 3$. At which of the following values of x does f have a relative maximum?

   A. –2 only

   B. –2, 1, and 4

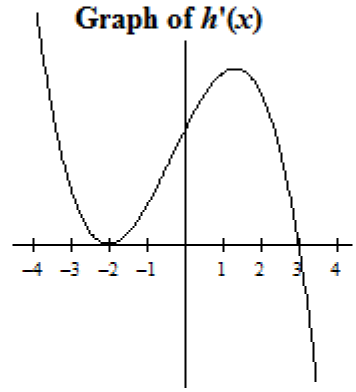
   C. 4 only

   D. –1 and 3 only



Graph of f'

5. Pictured to the right is the graph of $h'(x)$, the derivative of a function, $h(x)$. Which of the following statements is/are true?



I. The graph of $h(x)$ has a horizontal tangent when $x = 3$.

II. The graph of $h(x)$ is increasing on the interval $(-\infty, 3)$.

III. The graph of $h(x)$ is decreasing on the interval $(-\infty, -2)$.

A. I only B. II only C. I and II only D. I and III only

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6. Find $\lim_{h\to 0} \frac{\sin(x+h) - \sin x}{h} =$

A. $\cos x$ B. $\sin x$ C. $-\sin x$ D. $-\cos x$

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7. If $g'(1) = -3$, then which of the following could be the equation for $g(x)$?

I. $g(x) = 2x^2 - 7x + 3$ II. $g(x) = 4\sqrt{x} - 5x$ III. $g(x) = \frac{x^3 + 2x^2 + 4x}{x^2}$

A. I only B. I and II only C. I, II and III D. II and III only

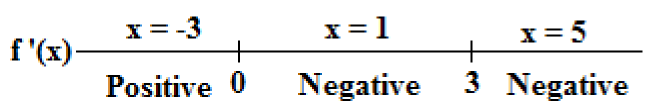
AP Calculus **Name________________________**

Multiple Choice

1. **B**
2. **A**
3. **B**
4. **C**
5. **A**
6. **A**
7. **C**

Free Response Part A – 3 points total

____ 1 Performs the sign analysis pictured to the right



____ 1 $f(x)$ has a relative maximum at $x = 0$ b/c $f'(x)$ changes from positive to negative.

____ 1 $f(x)$ does not have a relative minimum b/c $f'(x)$ never changes from negative to positive

Free Response Part B – 2 points total

____ 1 $f(x)$ is increasing on the interval $(-\infty, 0)$ b/c $f'(x) > 0$.

____ 1 $f(x)$ is decreasing on the intervals $(0, 3)$ and $(3, \infty)$ b/c $f'(x) < 0$.

Free Response Part C – 4 points total

____ 1 Finds the slope of the tangent line: $f'(2) = -2(2)(2-3)^2 = -4$

____ 1 Correct equation of the tangent line: $y + 3 = -4(x - 2)$ or $y = -4x + 5$

____ 1 Find that $f(2.1) \approx -4(2.1) + 5 \approx -8.4 + 5 \approx -3.4$

____ 1 Since $f(x)$ is concave up at $x = 2$, then the graph of the tangent line is below the graph of $f(x)$ so the tangent line approximation is an under estimation of the actual value.

MULTIPLE CHOICE

1. Which of the following statements can be made about the graph of the function $h(x) = \dfrac{\ln(\cos x)}{\tan x}$ when $x = \frac{\pi}{2}$.

   A. The graph of $h(x)$ is increasing.

   B. The graph of $h(x)$ is decreasing.

   C. No conclusion can be made about the graph of $h(x)$.

   D. The graph of $h(x)$ has a horizontal tangent.

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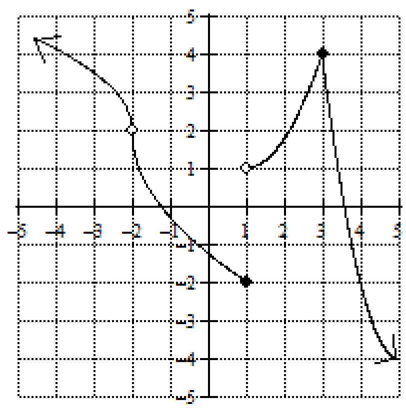
2. Consider the graph of $f(x)$ to the right to determine which of the following statements is/are true.

   I. $f'(x) = 0$ when $x = 3$.

   II. $f'(2.5) > 0$.

   III. On the interval $(-4, 5)$ there are three values of x at which $f(x)$ is not differentiable.



   A. II and III only
   B. I and II only
   C. III only
   D. I, II and III

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3. Let $f(7) = 0$, $f'(7) = 14$, $g(7) = 1$ and $g'(7) = \frac{1}{7}$. Find $h'(7)$ if $h(x) = \dfrac{f(x)}{g(x)}$.

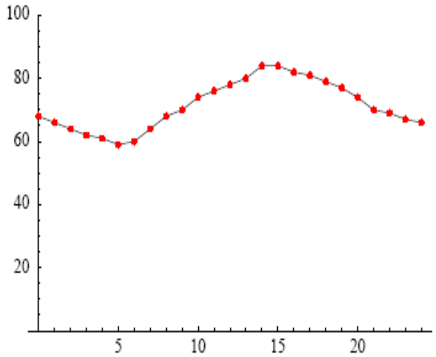
   A. 98

   B. –14

   C. –2

   D. 14

4. The graph to the right shows data of a function, $H(t)$, which shows the relationship between temperature in °C (y-axis) and the time in hours (x-axis). What does the value of $H'(6)$ represent?



A. $H'(6)$ represents the temperature after 6 hours measured in °C.
B. $H'(6)$ represents the rate at which the temperature is changing after 6 hours measured in °C.
C. $H'(6)$ represents the temperature after 6 hours measured in °C per hour
D. $H'(6)$ represents the rate at which the temperature is changing after 6 hours measured in °C per hour.

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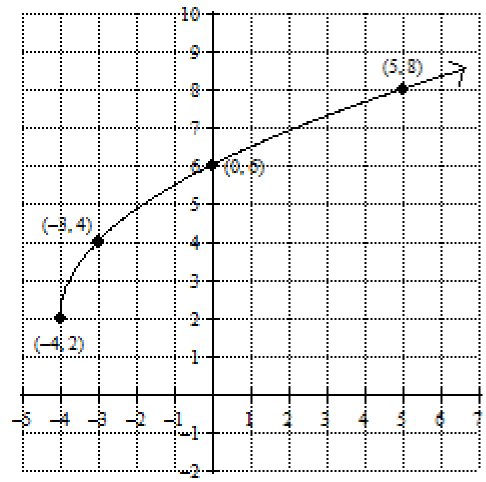
5. The graph of $h(x) = 2\sqrt{x+4} + 2$ is pictured. What is the value of $[h^{-1}(6)]'$?



A. $\frac{1}{4}$

B. 2

C. 4

D. $\frac{1}{2}$

6. Find y' if $y = x^2 e^x$.

   A. $2xe^x$
   B. $x\left(x+2e^x\right)$
   C. $xe^x(x+2)$
   D. $2x+e^x$

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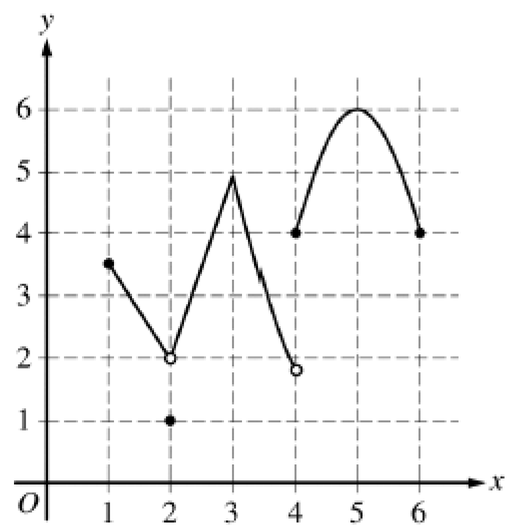
7. The function *f* is pictured to the right. At which of the following values of *x* is *f* defined and continuous but not differentiable.

   I. $x = 2$ II. $x = 3$ III. $x = 5$

   A. II only
   B. I only
   C. II and III only
   D. I and II only



Graph of *f*

FREE RESPONSE

The table shows values of differentiable functions, $f(x)$ and $g(x)$, and their derivatives at selected values of x. Use the table of values below to answer each of the questions below.

a. Approximate the value of $f'(1.5)$? Explain why your answer is a good approximation of $f'(1.5)$.

b. If $B(x) = \sqrt{g(x)}$, what is the equation of the tangent line drawn to $B(x)$ when $x = 1$?

x	$f(x)$	$f'(x)$	$g(x)$	$g'(x)$
0	3	−1	2	5
1	3	2	3	−3
2	5	3	1	−2
3	10	4	0	−1

The table shows values of differentiable functions, $f(x)$ and $g(x)$, and their derivatives at selected values of x. Use the table of values below to answer each of the questions below.

x	$f(x)$	$f'(x)$	$g(x)$	$g'(x)$
0	3	−1	2	5
1	3	2	3	−3
2	5	3	1	−2
3	10	4	0	−1

c. If $A(x) = x^2 \ln\left(f(x)\right)$, what is the value of $A'(2)$? What does this result say about the behavior of the graph of $A(x)$ when $x = 2$? Give a reason for your answer.

d. Find the value of $[g^{-1}(3)]'$. Then, find the equation of the line normal to the graph of $g^{-1}(x)$ at $x = 3$.

AP Calculus **Name________________________**

Multiple Choice

1. **C**
2. **A**
3. **D**
4. **D**
5. **B**
6. **C**
7. **A**

Free Response Part A – 2 points total

____ 1 $f'(1.5) \approx \frac{f(2)-f(1)}{2-1} \approx \frac{5-3}{1} \approx 2$

____ 1 $f'(1.5)$ is best approximated by finding the slope of a secant line passing through two points on the graph of $f(x)$ that lie on either side of $x = 1.5$ and the slope of the secant line should be approximately the same because the secant line is closely parallel to the tangent line.

Free Response Part B – 2 points total

____ 1 Finds $B'(x) = \frac{g'(x)}{2\sqrt{g(x)}}$ and evaluates $B'(1) = \frac{g'(1)}{2\sqrt{g(1)}} = \frac{-3}{2\sqrt{3}}$ to find the slope of the tangent line

____ 1 Equation of the tangent line using $B(1)$ and $B'(1)$: $y - \sqrt{3} = -\frac{3}{2\sqrt{3}}(x-1)$

Free Response Part C – 3 points total

____ 1 Correctly finds $A'(x) = 2x \cdot \ln(f(x)) + x^2 \cdot \frac{f'(x)}{f(x)}$

____ 1 $A'(2) = 2(2) \cdot \ln(f(2)) + (2)^2 \cdot \frac{f'(2)}{f(2)} = 4\ln(5) + 4 \cdot \frac{3}{5} = 4\ln 5 + \frac{12}{5} \approx 8.838$

____ 1 Since $A'(2) > 0$, then the graph of $A(x)$ is increasing when $x = 2$.

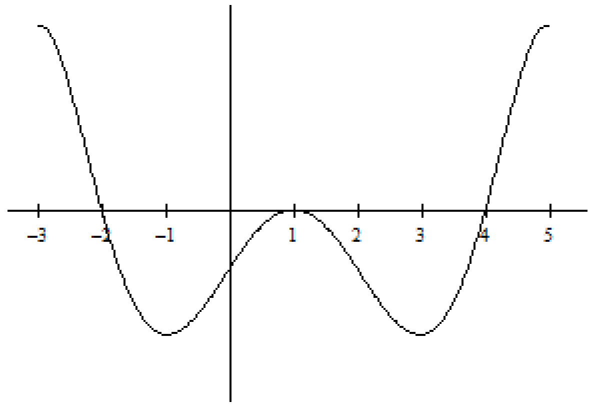
Free Response Part D – 2 points total

____ 1 Correctly finds $[g^{-1}(3)]' = \frac{1}{g'[g^{-1}(3)]} = \frac{1}{g'(1)} = -\frac{1}{3}$

____ 1 Correct equation of the normal line: $y - 1 = 3(x - 3)$

Calculator NOT Permitted Unit 4 PART I

Free Response



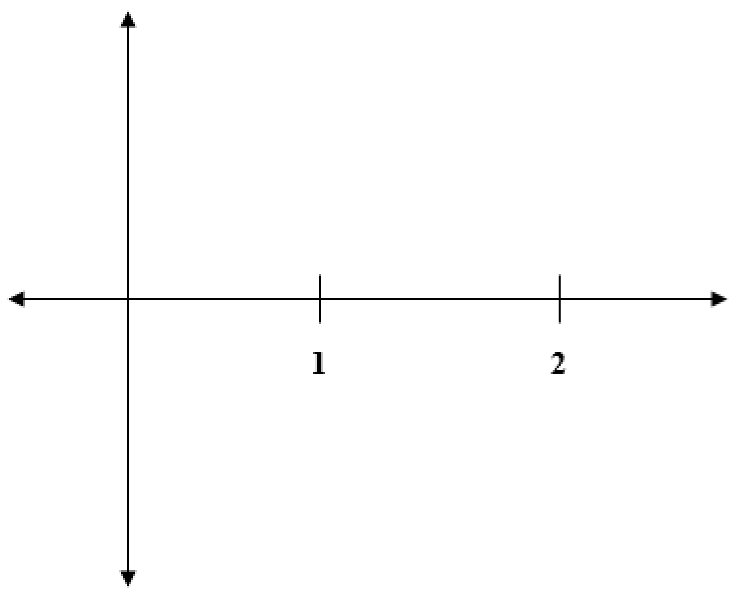
The figure above shows the graph of $f\,'(x)$, the derivative of $f(x)$. The domain of $f(x)$ is the set of all real numbers x such that $-3 < x < 5$.

a. At what value(s) of x does the graph of f have a horizontal tangent? Justify your answer.

b. On what open interval(s) is the graph of f increasing? Decreasing? Justify your answers.

c. On what open intervals is the graph of $f(x)$ concave upward? Justify your answer.

d. Suppose that $f(1) = 0$. In the xy-plane provided, draw a sketch that shows the general shape of the graph of the function $f(x)$ on the open interval $0 < x < 2$.



MULTIPLE CHOICE – Calculator NOT Permitted

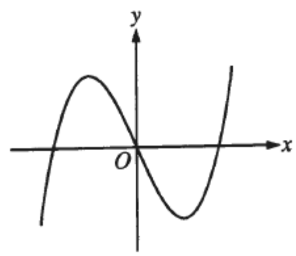
1. The graph of $y = 3x^2 - x^3$ has a relative maximum at…

A. (0, 0) only

B. (1, 2) only

C. (2, 4) only

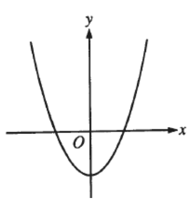
D. (0, 0) and (2, 4)



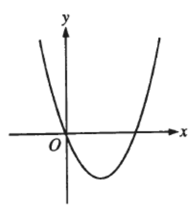
Graph of f

2. The graph of a function f is pictured above. Which of the following graphs could be the graph of its derivative, f'?

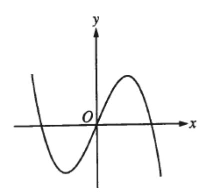
A.



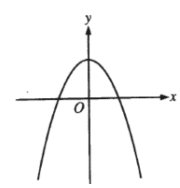
B.



C.



D.



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3. Let g be a twice–differentiable function with $g'(x) > 0$ and $g''(x) > 0$ for all real numbers x, such that $g(4) = 12$ and $g(5) = 18$. Of the following, which is a possible value for $g(6)$?

A. 15 B. 18 C. 21 D. 27

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4. Determine which of the following statements is/are true about the functions $f(x)$, $f'(x)$ and $f''(x)$.

I. If $f'(x) = 0$ when $x = c$ and $f''(c) > 0$, then $x = c$ is a relative minimum of $f(x)$.

II. If $f'(x)$ is positive, then the graph of $f(x)$ is increasing.

III. If $f(x)$ has a point of inflection, then $f'(x)$ has a relative maximum or minimum.

A. I and II B. I, II, and III C. II only D. II and III only

5. The second derivative of a function is given by $F''(x) = (x - 2)^2(x + 3)$. Which of the following conclusions can be made?

   I. $F(x)$ is concave up on $(-3, 2)$ and $(2, \infty)$.

   II. $F(x)$ has a point of inflection at $x = -3$.

   III. $F'(x)$ has a relative maximum at $x = -3$.

   A. I and II only B. II only C. I and III only D. II and III only

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6. If $g(x) = 2kx^{3/2} + 2x\ln x$, for what value(s) of k would $g(x)$ have a horizontal tangent at $x = 4$?

   A. $-\frac{\ln 4}{2}$ B. $-\frac{1}{12}$

   C. $-\frac{1+\ln 4}{3}$ D. $\frac{-2+2\ln 4}{3}$

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7. The total number of relative minimums of the function $F(x)$ whose derivative, for all x, is given by $F'(x) = x(x-3)(x+1)^4$ is…

   A. 3
   B. 2
   C. 1
   D. 0

Multiple Choice

1. **C**
2. **A**
3. **D**
4. **B**
5. **A**
6. **C**
7. **C**

Calculator NOT Permitted Free Response Part A – 2 points total

____ 1 The graph of $f(x)$ has a horizontal tangent anytime that $f'(x) = 0$.

____ 1 The graph of $f'(x)$ is on the x – axis at $x = -2$, 1, and 4.

Calculator NOT Permitted Free Response Part B – 2 points total

____ 1 $f(x)$ is increasing when the graph of $f'(x) > 0$ which occurs on $(-3,-2)\cup(4,5)$.

____ 1 $f(x)$ is decreasing when the graph of $f'(x) < 0$ which occurs on $(-2,1)\cup(1,4)$.

Calculator NOT Permitted Free Response Part C – 3 points total

____ 1 $f(x)$ is concave up when $f''(x) > 0$.

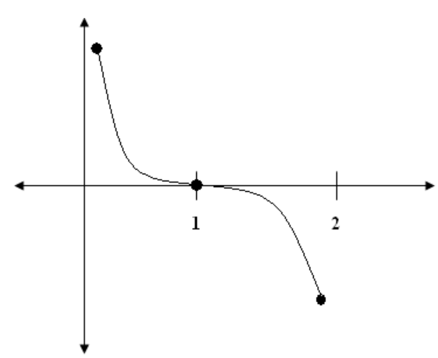
____ 1 When $f'(x)$ is increasing, then $f''(x) > 0$.

____ 1 Since $f'(x)$ is increasing on the intervals (–1, 1) and (3, 5), then $f(x)$ is concave up on these intervals.

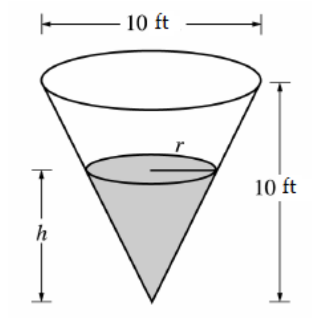
Calculator NOT Permitted Free Response Part D – 2 points total

____ 1 The graph is decreasing and concave up on the interval (0, 1)

____ 1 The graph is decreasing and concave down on the interval (1, 2)



Free Response #1



Water is running into an open conical tank at the rate of 9 cubic feet per minute. The tank is standing, inverted, and has a height of 10 feet and a base diameter of 10 feet.

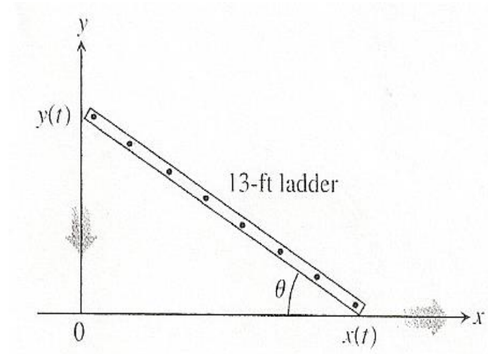
[Remember, the volume of a cone is given by the formula $V = \frac{1}{3}\pi r^2 h$.]

a. At what rate is the radius of the water in the tank increasing when the radius is 2 feet?

b. At what rate is the exposed surface area of the water changing when the radius is 2 feet?

Free Response #2

A 13 foot ladder is leaning against a house when its base starts to slide away. By the time the base is 12 feet from the house, the base is moving at the rate of 5 feet per second.



a. How fast is the top of the ladder sliding down the wall at the when the base of the ladder is 12 feet from the side of the house?

b. At what rate is the angle, θ, between the ladder and the ground changing when the ladder is 12 feet from the side of the house?

Free Response #3

Consider the closed curve in the *xy* – plane given by the equation $x^2 + 2x + y^4 + 4y = 5$.

a. Show that $\frac{dy}{dx} = -\frac{x+1}{2(y^3+1)}$.

b. Find the equation of the line normal to the curve at the point (−2, 1).

c. Find the coordiates of the two points on the curve where the line tangent to the curve is vertical.

MULTIPLE CHOICE − Calculator Permitted

1. If $x = 1$ and $y = 2$, then what is the value of $\frac{dy}{dx}$ for the curve defined by $e^{2y} + xy = 3x^2$?

   A. $\frac{6}{2e^4+1}$ B. $\frac{4}{2e^4+1}$

   C. $\frac{2}{e^4+1}$ D. $\frac{6}{e^4}$

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2. The radius of a circle is increasing at a constant rate of 2 meters per second. What is the rate of increase in the area of the circle at the instant when the circumference of the circle is 20π meters?

   A. $0.04\pi\ m^2/\sec$
   B. $40\pi\ m^2/\sec$
   C. $4\pi\ m^2/\sec$
   D. $20\pi\ m^2/\sec$

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3. If $xy^2 - y^3 = x^2 - 5$, then $\frac{dy}{dx} =$

   A. $\frac{2x}{2y-3y^2}$ B. $\frac{y^2-2x+5}{3y^2-2xy}$

   C. $\frac{2x-5}{2y-3y^2}$ D. $\frac{y^2-2x}{3y^2-2xy}$

4. A spherical snowball is melting in such a way that its volume is decreasing at a rate of 2 $cm^3/\min$. At what rate is the radius decreasing when the radius is 7 cm?

[The volume of a sphere is given by $V = \frac{4}{3}\pi r^3$.]

A. $\frac{1}{7\pi} cm/\min$

B. $\frac{1}{49\pi} cm/\min$

C. $\frac{1}{98\pi} cm/\min$

D. $\frac{1}{196\pi} cm/\min$

5. The surface area of a cube is decreasing at a rate of 72 square inches per minute. What is the rate of change of the volume of the cube when the length of an edge of the cube is 3 inches?

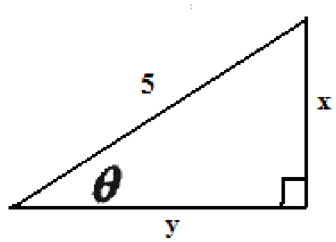
A. -54 in^3/min

B. -27 in^3/min

C. -18 in^3/min

D. -2 in^3/min

6.



In the triangle shown above, if θ increases at a constant rate of 3 radians per minute, at what rate is y decreasing in units per minute when x equals 3 units?

A. 3

B. $\frac{15}{4}$

C. 4

D. 9

7. What is the slope of the tangent line to the curve $y^2 - 2x^2 = 6 - 2xy$ at the point (2, 3)?

A. $\frac{1}{5}$

B. $\frac{4}{9}$

C. $\frac{7}{9}$

D. $\frac{6}{7}$

8. The radius of a sphere is decreasing at a rate of 2 centimeters per second. At the instant when the radius of the sphere is 3 centimeters, what is the rate of change, in square centimeters per second, of the surface area of the sphere? (The surface area, S, of a sphere with radius r is $S = 4\pi r^2$.)

A. -108π

B. -72π

C. -48π

D. -24π

AP Calculus Name________________________

Multiple Choice

1. **B**
2. **B**
3. **D**
4. **C**
5. **A**
6. **D**
7. **A**
8. **C**

Free Response #1 Part A – 3 points total

_____ 1 Rewrites the volume formula correctly in terms of only V and r: $V = \frac{1}{3}\pi r^2 h = \frac{1}{3}\pi r^2(2r) = \frac{2}{3}\pi r^3$

_____ 1 Correctly differentiates implicitly with respect to time: $\frac{dV}{dt} = 2\pi r^2 \frac{dr}{dt}$

_____ 1 Answer with correct units: $\frac{9}{8\pi}$ feet per minute

Free Response #1 Part B – 3 points total

_____ 1 Correctly differentiates the area of a circle ($A = \pi r^2$) with respect to time: $\frac{dA}{dt} = 2\pi r \frac{dr}{dt}$

_____ 1 Uses the value from part a) for $\frac{dr}{dt} = \frac{9}{8\pi}$: $\frac{dA}{dt} = 2\pi(2)\frac{9}{8\pi}$

_____ 1 Answer with correct units: $\frac{9}{2}$ ft^2 per minute

Free Response #2 Part A – 3 points total

_____ 1 Substitutes the value for the length of the ladder into the equation before differentiating: $x^2 + y^2 = 13^2$

_____ 1 Correctly differentiates implicitly with respect to time: $2x\frac{dx}{dt} + 2y\frac{dy}{dt} = 0$

_____ 1 Answer with correct units: $\frac{dy}{dt} = -12$ feet per second

Free Response #2 Part B – 3 points total

_____ 1 Uses an appropriate trigonometric equation

_____ 1 Correctly differentiates implicitly with respect to time

_____ 1 Answer with correct units

$\sin\theta = \frac{y}{13}$	$\cos\theta = \frac{x}{13}$	$\tan\theta = \frac{y}{x}$
$\cos\theta\frac{d\theta}{dt} = \frac{1}{13}\frac{dy}{dt}$	$-\sin\theta\frac{d\theta}{dt} = \frac{1}{13}\frac{dx}{dt}$	$\sec^2\theta\frac{d\theta}{dt} = \frac{x\cdot\frac{dy}{dt} - y\frac{dx}{dt}}{x^2}$
$\left(\frac{12}{13}\right)\frac{d\theta}{dt} = \frac{1}{13}(-12)$ $\frac{d\theta}{dt} = -1$ rad/sec	$-\left(\frac{5}{13}\right)\frac{d\theta}{dt} = \frac{1}{13}(5)$ $\frac{d\theta}{dt} = -1$ rad/sec	$\left(\frac{13}{12}\right)^2\frac{d\theta}{dt} = \frac{12(-12)-5(5)}{12^2}$ $\frac{d\theta}{dt} = -1$ rad/sec

Free Response #3 Part A – 2 points total

_____ 1 Correctly differentiates: $2x+2+4y^3\frac{dy}{dx}+4\frac{dy}{dx}=0$

_____ 1 Correctly solves for $\frac{dy}{dx}=\frac{-2x-2}{4y^3+4}=\frac{-2(x+1)}{4(y^3+1)}=\frac{-(x+1)}{2(y^3+1)}=-\frac{x+1}{2(y^3+1)}$

Free Response #3 Part B – 2 points total

_____ 1 Correctly finds the value of $\frac{dy}{dx}=-\frac{x+1}{2(y^3+1)}$ at the point (−2, 1) to be $\frac{1}{4}$

_____ 1 Uses the opposite reciprocal of the slope, −4, to write the equation of the normal line to be $y-1=-4(x+2)$

Free Response #3 Part C – 2 points total

_____ 1 Sets the denominator of $\frac{dy}{dx}$, $2(y^3+1)=0$, and correctly solves for $y=-1$.

_____ 1 Substitutes $y=-1$ into the equation of the curve, $x^2+2x+y^4+4y=5$, and correctly solves for $x=-4$ and $x=2$. The two points are (−4, −1) and (2, −1)