Mount Olive High School
Summer Assignment
for
AP Calculus BC

Students who are responsible for completing this packet:
Anyone entering: AP Calculus BC

Directions:

PART I: Free Response Questions
There are six free response questions, based off of Calculus AB topics, that you are required to complete and hand in on the first day of school. Make sure to bring in the completed questions to class on the first day of school.

The questions will be graded on work shown, explanations / justifications and correctness. All problems are to be completed or well attempted. Show work on every problem in the space provided for partial credit; crossed out or erased work will not be graded. Write neatly and circle, highlight or box final answers.

PART II: Skills Test Review
You will be given a Skills Test on the first full day of school. The skills test will be a multiple-choice, NON-calculator section of a sample AP Calculus AB exam. The practice multiple-choice questions in this summer assignment are a review for this test and DO NOT NEED TO BE HANDED IN; they are only for practice and the answers are given on the back.

NOTE:
Only PART I of this summer assignment will be collected, PART II is a review for the skills test that will be given on the first week of school.
PART I: Free Response Questions

Complete all six free response questions in this section and hand in on the first day of school. Make sure to show all work and explain where needed.

1. Use the graphs of \( f(x) \) and \( g(x) \) given below to answer the following questions:

![Graphs of f(x) and g(x)]

a. Is \( f(g(x)) \) continuous at \( x = 0 \)? Explain why or why not.
b. Is \( g(f(x)) \) continuous at \( x = 0 \)? Explain why or why not.
c. What is \( \lim_{x \to 0} f(g(x)) \)? Explain your reasoning.
d. If \( h(x) = \begin{cases} f(x) + g(x), & -2 \leq x < 0 \\ k \cdot g(x) f(x), & x \geq 0 \end{cases} \), what is \( k \) so that \( h(x) \) is continuous at \( x = 0 \)?
2. A solution is draining through a conical filter into an identical conical container as shown in the diagram to the right. The solution drips from the upper filter into the lower container at a rate of \( \pi \text{ cm}^3/\text{sec} \) \( (V_{\text{cone}} = \frac{\pi}{3} r^2 h) \).

   a. How fast is the level in the upper filter dropping when the solution level in the upper filter is at 6 cm?

   b. If the conical filter is initially full, what is the level of the solution in the lower level when the solution level in the upper filter is at 6 cm and how fast is the level in the lower filter rising?

   c. How fast is the surface area of the solution in the lower filter increasing when the volume in the upper filter equals the volume in the lower container?
3. A differentiable function $f(x)$ is defined such that, for all values of $x$
in its domain, $f(x) = 3 + \int_0^x f(\sqrt{t}) \, dt$.
   a. What is the domain of $f(x)$?
   b. For what value(s) of $x$ is $f(x) = 3$?
   c. Show that $f'(x) = 3x^2 f(x)$.
   d. Solve the differential equation in (c) to find $f(x)$ in terms of $x$
      only.
4. An isosceles triangle is inscribed in a semicircle, as shown in the diagram, and it continues to be inscribed as the semicircle changes size. The area of the semicircle is increasing at the rate of 1 cm$^2$/sec when the radius of the semicircle is 3 cm.
   a. How fast is the radius of the semicircle increasing when the radius is 3 cm? Include units in your answer.
   b. How fast is the perimeter of the semicircle increasing when the radius is 3 cm? Include units in your answer.
   c. How fast is the area of the isosceles triangle increasing when the radius is 3 cm? Include units in your answer.
   d. How fast is the shaded region increasing when the radius is 3 cm? Include units in your answer.
5. Let \( f \) be the function given by \( f(x) = e^x + 1 \) as shown in the sketch below, where the region \( R \) is bounded by the graph of \( f(x) \), the \( y \)-axis, and the horizontal line \( y = 4 \).

![Graph](image)

a. Find the area of the region \( R \).
b. A vertical line \( x = h \), where \( h > 0 \) is chosen so that the area of the region bounded by \( f(x) \), the \( y \)-axis, the horizontal line \( y = 4 \), and the line \( x = h \) is half the area of region \( R \). What is the value of \( h \)?
c. Find the volume of the solid formed when region \( R \) is rotated about the line \( y = 4 \).
d. A horizontal line \( y = k \), where \( k \) is greater than 4, is chosen so that the volume of the solid formed when region \( R \) is rotated about the line \( y = k \) is twice the volume of the solid found in part (c). Set up, but do not evaluate, an integral expression in terms of a single independent variable which represents the volume of this solid.
6. Let $f$ be a function defined in the closed interval $0 \leq x \leq 6$. The graph of $f$ consists of three line segments and a semicircle. Let

$$g(x) = 3 + \int_0^x f(t) \, dt.$$ 

a. Find $g(1)$, $g'(1)$, and $g''(1)$.
b. What is the average rate of change of $g(x)$ in the interval $2 \leq x \leq 6$?
c. What is the average value of $g(x)$ in the interval $2 \leq x \leq 6$?
d. Identify the $x$-coordinate of any extrema of $g(x)$ in $0 < x < 6$. Explain your reasoning.
e. Identify the $x$-coordinate of any points of inflection of $g(x)$ in $0 < x < 6$.
PART II: Skills Test Review
Use the following multiple-choice questions as a review for the NON-calculator skills test given on the first full day of school; answers on back.

AP CALCULUS BC Practice TEST 1
Section I, Part A: Multiple-Choice Questions
Time: 55 minutes
Number of Questions: 28

A calculator may not be used on this part of the examination.

1. What is \( \int \frac{x-3}{x} \, dx \)?
   (A) \( 1 - 3 \ln x + C \)
   (B) \( x - 3 \ln x + C \)
   (C) \( 1 + \frac{3}{x} + C \)
   (D) \( \frac{x^2 - 3x}{x^2} + C \)
   (E) \( \frac{x^3}{2} - 3 \ln x + C \)

2. What is the value of \( \lim_{x \to 1} \frac{x^2 - 3x - 4}{x^2 - 1} \)?
   (A) \( \frac{5}{2} \)
   (B) 1
   (C) 0
   (D) \( -\frac{5}{2} \)
   (E) The limit does not exist.

3. What is the equation of the tangent to \( f(x) = 3x - 5 \cos 2x \) at \( x = 0 \)?
   (A) \( x = -5x - 3 \)
   (B) \( y = -5x + 3 \)
   (C) \( y = 3x + 5 \)
   (D) \( y = 3x - 5 \)
   (E) \( y = x - 5 \)

4. A particle moves along the y-axis so that its position at any time \( t \), for \( 0 \leq t \leq 5 \), is given by \( y(t) = t^4 - 18t^3 \).
   In which interval(s) is the particle speeding up?
   (A) \( 0 < t < \sqrt{3} \)
   (B) \( 0 < t < \sqrt{3} \) and \( 3 < t < 5 \)
   (C) \( 3 < t < 5 \)
   (D) \( \sqrt{3} < t < 3 \) and \( 3 < t < 5 \)
   (E) \( \sqrt{3} < t < 3 \)

5. Which of the following statements is (are) false for \( f(x) = e^x \sin x \)?
   I. \( \lim_{x \to \infty} f(x) = 0 \)
   II. \( \lim_{x \to 0} f'(x) = 1 \)
   III. \( \lim_{x \to \infty} f''(x) = 2 \)
   (A) I only
   (B) II only
   (C) III only
   (D) II and III only
   (E) None of the statements is false.

6. The region \( R \), bounded by \( f(x) \), \( g(x) \), and the x-axis, is shown in the diagram above. Which one of the following integrals represents the volume of the solid generated when \( R \) is rotated about the line \( y = 1 \)?
   (A) \( \pi \int_0^1 [1 - f(x)]^2 \, dx + \pi \int_1^2 [1 - g(x)]^2 \, dx \)
   (B) \( \pi \int_0^1 [t^2 - [1 - f(x)]^2] \, dx + \pi \int_1^2 [t^2 - [1 - g(x)]^2] \, dx \)
   (C) \( \pi \int_0^1 [1 - [f(x)]^2] \, dx + \pi \int_1^2 [1 - [g(x)]^2] \, dx \)
   (D) \( \pi \int_0^1 [1 - f(x)] \, dx + \pi \int_1^2 [1 - g(x)] \, dx \)
   (E) none of these
7. Let \( f(x) = (3 + 2x - x^3)^3 \) be defined for the closed interval \(-2 \leq x \leq 3\). If \( M \) is the \( y \)-coordinate of the absolute maximum and \( m \) is the \( y \)-coordinate of the absolute minimum, what is \( |M + m| \)?
   (A) 189
   (B) 125
   (C) 64
   (D) 61
   (E) none of these

8. Find the equation of the curve that passes through the point \((1, 2)\) and has a slope of \( \left(3 + \frac{1}{x}\right)y\) at any point \((x, y)\) on the curve.
   (A) \(2xe^{3x-3}\)
   (B) \(2xe^{3x-2}\)
   (C) \(2xe^3\)
   (D) \(2e^{3x-3}\)
   (E) none of these

9. A continuous function \( h(t) \) is defined in the closed interval \( 10 \leq t \leq 16 \) with values given in the table below. Using the data, find the trapezoidal approximation with three subintervals of unequal length to estimate \( \int_{10}^{16} h(t) \, dt \).

<table>
<thead>
<tr>
<th>( t )</th>
<th>( h(t) )</th>
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<tbody>
<tr>
<td>10</td>
<td>10</td>
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<td>12</td>
<td>20</td>
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<td>15</td>
<td>50</td>
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<td>16</td>
<td>80</td>
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</tbody>
</table>

   (A) \(\frac{359}{3}\)
   (B) 130
   (C) 200
   (D) 270
   (E) 718

10. Find the \( x \)-coordinate of the point on \( f(x) = \frac{4}{\sqrt{x}} \) that is closest to the origin.
    (A) 1
    (B) 2
    (C) \(2\sqrt{2}\)
    (D) \(2\sqrt{2}\)
    (E) \(2\sqrt{2}\)

11. Evaluate \( \lim_{x \to \infty} \frac{3 - \sqrt{x^2 - 1}}{2x + 5} \).
    (A) \(-\frac{1}{2}\)
    (B) 0
    (C) \(\frac{3}{2}\)
    (D) \(\frac{3}{2}\)
    (E) The limit does not exist.

12. If \( \tan y + x^3 = y^3 + 1 \) and \( \frac{dy}{dt} = -2 \), what is the value of \( \frac{dy}{dt} \) at the point \((1, 0)\)?
    (A) -6
    (B) -2.5
    (C) 0
    (D) \(\frac{1}{2\cos 1^2}\)
    (E) 6

13. A particle moves in a line with velocity \( v(t) = 3t^2 - e^t \). What is the average velocity of the particle in the closed interval \( 0 \leq t \leq 2 \)?
    (A) \(\frac{8-e^2}{2}\)
    (B) \(\frac{9-e^2}{2}\)
    (C) \(\frac{11-e^2}{2}\)
    (D) \(\frac{13-e^2}{2}\)
    (E) \(13-e^2\)
14. What is the value of $k + c$ if
   \[ f(x) = \begin{cases} 
   2kx^2 - x, & x > 3 \\
   x^3 + cx, & x \leq 3 
   \end{cases} \]
   is everywhere differentiable?
   (A) $\frac{5}{4}$
   (B) 3
   (C) 8
   (D) 11
   (E) 24

15. A particle moves along the $x$-axis with a velocity given by \( v(t) = t - \frac{\sqrt{t}}{t} \) for \( 0 \leq t \leq 8 \). If the particle is 4 units to the left of the origin at \( t = 0 \), where is the particle at \( t = 8 \)?
   (A) 24 units to the right of the origin
   (B) 20 units to the right of the origin
   (C) 16 units to the right of the origin
   (D) 1 1/2 units to the left of the origin
   (E) 3 1/2 units to the left of the origin

16. \( \int \frac{x + 1}{x} \, dx = \)
   (A) 17
   (B) 17.5
   (C) 18.5
   (D) 19
   (E) 19.5

17. \( \int \frac{x^3 + 2}{x^2 + 1} \, dx = \)
   (A) \( \ln(x^2 + 1) + C \)
   (B) \( \frac{x^2}{2} + 2x \ln(x^2 + 1) + C \)
   (C) \( \frac{1}{2} \ln(x^2 + 1) + C \)
   (D) \( \frac{1}{2} \ln(x^2 + 1) + 2 \tan^{-1}(x^2) + C \)
   (E) \( \frac{1}{2} \ln(x^2 + 1) + 2 \tan^{-1}(x) + C \)

18. The tangent line to the graph of \( g(x) \) at the point \( (3, 5) \) has a slope of \(-2\). Use the equation of the tangent to estimate \( g(2.98) \).
   (A) 2.50
   (B) 4.98
   (C) 5.02
   (D) 5.04
   (E) 7.02

19. Which of the following is the slope field for \( \frac{dy}{dx} = \frac{e^x}{y} \)?
   (A) ![Graph A](image)
   (B) ![Graph B](image)
   (C) ![Graph C](image)
   (D) ![Graph D](image)
   (E) ![Graph E](image)
20. Consider the piecewise function,
\[
g(x) = \begin{cases} 
  e^{x+c}, & x < 10 \\
  3, & x = 10 \\
  \log(x) + 1, & x > 10 
\end{cases}
\]
Find the value of \( c \) so that \( \lim_{x \to 10} g(x) \) exists.
A) 3
B) 2
C) 1
D) \log 2 - 1
E) The limit does not exist.

21. If \( y = 4^x \), what is \( y'(1) \)?
(A) 0
(B) ln 4
(C) 2 ln 4
(D) 1 + 2 ln 4
(E) 4 ln 4

22. What is the value of \( g(2) \) if
\[
g(x) = 3 + \frac{d}{dx} \left[ \int_0^x (1 + t^3) \, dt \right]
\]
(A) 8
(B) 20
(C) 23
(D) 24
(E) 71

23. Which of the following statements is true for \( f(x) = \frac{1 + e^x}{e^x - 1} \)?
(A) \( f(x) \) has a relative maximum at \( x = 1 \).
(B) \( f(x) \) has a y-intercept at \( x = 0 \).
(C) \( f(x) \) has a root of 0.
(D) \( f(x) \) is decreasing for all \( x \), \( x \neq 0 \).
(E) \( f(x) \) has a vertical asymptote at \( x = 1 \).

24. A particle moves along the x-axis. At which time on the velocity versus time graph given above is the particle farthest left of its starting point?
(A) A
(B) B
(C) C
(D) D
(E) E

25. If \( \sin(xy) = x + y \), what is \( \frac{dy}{dx} \)?
\[
\begin{align*}
(A) & \quad \frac{y \cos xy + 1}{1 - x \cos xy} \\
(B) & \quad \frac{y \cos xy - 1}{1 - x \cos xy} \\
(C) & \quad \frac{\cos xy - 1}{1 - x \cos xy} \\
(D) & \quad \frac{1}{\cos xy - 1} \\
(E) & \quad \frac{\cos x - 1}{1 - \cos y}
\end{align*}
\]
26. What is \( g(0) \)?
(A) 4  
(B) 2  
(C) 0  
(D) -2  
(E) -4

27. What is the equation of the tangent to \( g(x) \) at the point \( (3, g(3)) \)?
(A) \( y = 0 \)  
(B) \( y = 1 \)  
(C) \( y = x - 3 \)  
(D) \( y = x + 3 \)  
(E) \( y = -3 \)

28. Which of the following is false for \( g(x) \)?
(A) \( g(x) \) has a relative maximum at \( x = -1 \).
(B) \( g(x) \) has a relative minimum at \( x = 3 \).
(C) \( g(x) \) has a relative maximum at \( x = -2 \).
(D) \( g(x) \) is decreasing in the interval \( 2 < x < 3 \).
(E) \( g(x) \) is increasing in the interval \( -2 < x < -1 \).

Section I. Part B: Multiple-Choice Questions
Time: 50 minutes
Number of Questions: 17

A calculator may be used on this part of the examination.

29. What is the area of the first closed region to the left of the \( y \)-axis, bounded by the curves \( f(x) = -\tan x \) and \( g(x) = 2x^4 \)?
(A) 1.206  
(B) 0.931  
(C) 0.891  
(D) 0.452  
(E) 0.240

30. What is the average rate of change of \( f(x) = \frac{e^x}{x} \) in the interval \( -4 \leq x \leq -1 \)?
(A) 0.106  
(B) 0.137  
(C) 0.319  
(D) 0.411  
(E) 1.233
31. Consider the integral expression
\[ \int_{0}^{\frac{\pi}{2}} \sin(2x) e^{\sin(2x)} \, dx \]. If \( u = \cos 2x \), then which integral below is equivalent to the given integral?
(A) \( -\frac{1}{2} \int_{0}^{1} e^{u} \, du \)
(B) \( -2 \int_{0}^{1} e^{u} \, du \)
(C) \( -\frac{1}{2} \int_{-1}^{1} e^{u} \, du \)
(D) \( \frac{1}{2} \int_{-1}^{1} e^{u} \, du \)
(E) \( 2 \int_{-1}^{1} e^{u} \, du \)

32. Let \( f(x) = \frac{1}{x} \) and \( k > 1 \). If the area between the \( x \)-axis and the graph of \( f(x) \) in the closed interval \( k \leq x \leq k + 1 \) is 0.125 where \( k > 1 \), then what is the value of \( k \)?
(A) 0.133
(B) 1.133
(C) 1.334
(D) 2.998
(E) 7.510

33. A solid has its base in the \( xy \)-plane, bounded by the \( x \)-axis, the \( y \)-axis, and the function \( y = 3 - x^2 \). If cross sections taken perpendicular to the \( x \)-axis are semicircles whose diameters are in the \( xy \)-plane, what is the volume of this solid?
(A) 3.325
(B) 4.247
(C) 5.239
(D) 6.671
(E) 13.342

34. Shampoo drips from a crack in the side of a plastic bottle at a rate modeled by \( Y(t) = \frac{t}{\sqrt{1 + t^3}} \), where \( Y(t) \) is in ounces per minute. If there are 32 ounces in the bottle at \( t = 0 \), how many ounces are left in the bottle after 5 minutes?
(A) 26.937 ounces
(B) 24.355 ounces
(C) 7.645 ounces
(D) 5.063 ounces
(E) The bottle will be empty before 5 minutes has elapsed.

35. Consider the function \( f(x) = x^3 + 2 \) in the closed interval \( 0 < a \leq c \leq 2 \). If the value guaranteed by the Mean Value Theorem in the closed interval is \( c = 1.720 \), then what is the value of \( a \)?
(A) 1.260
(B) 1.424
(C) 1.602
(D) 1.800
(E) none of these

36. The sketch of \( f(x) \) is shown below, with regions bounded by \( f(x) \) and the \( x \)-axis indicated by \( \mathcal{L} \), \( \mathcal{Q} \), and \( R \). If \( \int_{a}^{b} f(x) \, dx = -7 \), \( \int_{c}^{d} f(x) \, dx = -2 \), and \( \int_{e}^{f} f(x) \, dx = 17 \), what is \( \int_{0}^{2} f(x) \, dx \)?
(A) -12
(B) -6
(C) -3
(D) 4
(E) none of these
37. Let \( h(x) = xg(x) \), where 
\( g(x) = f^{-1}(x) \). Use the table of values below to find \( h'(5) \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) )</th>
<th>( f'(x) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

- (A) \( \frac{1}{2} \)
- (B) 2.5
- (C) 3
- (D) \( \frac{2}{3} \)
- (E) 5.5

38. Let \( f(x) = \sin x \) and \( g(x) = p \ln x \) in the closed interval \( 0 \leq x \leq \frac{\pi}{2} \). For what value of \( p \) will the tangents to the curves at their points of intersection be perpendicular?

- (A) 0.447
- (B) 0.410
- (C) 1.260
- (D) 1.303
- (E) none of these

39. The height of a conical sand pile is always twice the radius. If sand is being added to the pile at a rate of 30\( \pi \) cm\(^3\)/min, how fast is the height of the pile increasing when the circumference of the base of the sand pile is 120\( \pi \) cm?

\( V_{	ext{cone}} = \frac{\pi}{3} r^2 h \)

- (A) \( \frac{1}{120\pi} \) cm/min
- (B) \( \frac{1}{120} \) cm/min
- (C) \( \frac{2}{15} \) cm/min
- (D) \( \frac{1}{4} \) cm/min
- (E) none of these

40. The graphs of \( f(x) \) and \( g(x) \) are shown above. If \( h(x) = g(2x) \), use the graphs to find \( h'(1) \).

- (A) 7
- (B) \( \frac{7}{16} \)
- (C) \( \frac{7}{16} \)
- (D) \( \frac{5}{16} \)
- (E) \( \frac{3}{16} \)

41. The number of home fires each day in a certain city increases as the temperature drops. The rate of home fires is modeled by 
\( F(t) = 4 \cos \left( \frac{t}{58} - 2 \right) + 6 \) for \( 0 \leq t \leq 365 \) days, where midnight on January 1st corresponds to \( t = 0 \). Which of the following is closest to the approximate number of fires in the first quarter of the year?

- (A) 910
- (B) 660
- (C) 540
- (D) 330
- (E) 240

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42. The graphs of the derivatives of three functions, \(f, g,\) and \(h,\) are given below. Which of the functions has at least one point of inflection in the open interval \(-3 < x < 2?\)

<table>
<thead>
<tr>
<th>(x)</th>
<th>(f)</th>
<th>(g)</th>
<th>(f')</th>
<th>(g')</th>
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<td>3</td>
<td>4</td>
<td>(\frac{3}{2})</td>
<td>(-\frac{3}{2})</td>
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<tr>
<td>2</td>
<td>4</td>
<td>2</td>
<td>(\frac{4}{3})</td>
<td>(-\frac{2}{3})</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>1</td>
<td>(\frac{5}{3})</td>
<td>(\frac{1}{3})</td>
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</table>

43. If \(f(x)\) and \(g(x)\) are differentiable functions with values as given in the chart above, and \(k(x) = f(g(x^2)),\) what is \(k'(2)?\)

(A) \(\frac{1}{3}\)
(B) \(\frac{2}{3}\)
(C) \(\frac{4}{3}\)
(D) \(\frac{16}{3}\)
(E) none of these

44. The price of a newly issued stock varies sinusoidally during the first 10 days after its initial offering and is modeled by

\[ P(t) = \log(2t + 1) \sin t + 20, \]

where \(t\) is in days. To the nearest cent, what is the price of the stock when the price of the stock is decreasing most rapidly in the interval \(0 \leq t \leq 10?\)

(A) \$7.98
(B) \$9.49
(C) \$19.91
(D) \$20.12
(E) \$21.22

45. The graph of \(g'(x)\) is shown on the graph to the left. For which of the stated interval(s) is the function \(g(x)\) both increasing and concave up?

(A) \(a < x < b\)
(B) \(e < x < f\)
(C) \(a < x < b\) and \(e < x < f\)
(D) \(a < x < c\) and \(e < x < h\)
(E) \(a < x < b\) and \(d < x < f\)
**Answers**

Using the table below, score your test. Determine how many questions you answered correctly and how many you answered incorrectly.

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