CALCULUS AB
SECTION I, Part A
Time—55 minutes
Number of questions—28

Name ___________________
Periods ______

A CALCULATOR MAY NOT BE USED ON THIS PART OF THE EXAM.

1. $\int_2^x (3t^2 - 1)\,dt =$

(A) $x^3 - x - 6$ (B) $x^3 - x$ (C) $3x^2 - 12$ (D) $3x^2 - 1$ (E) $6x - 12$

2. What is the slope of the line tangent to the graph of $y = \ln(2x)$ at the point where $x = 4$?

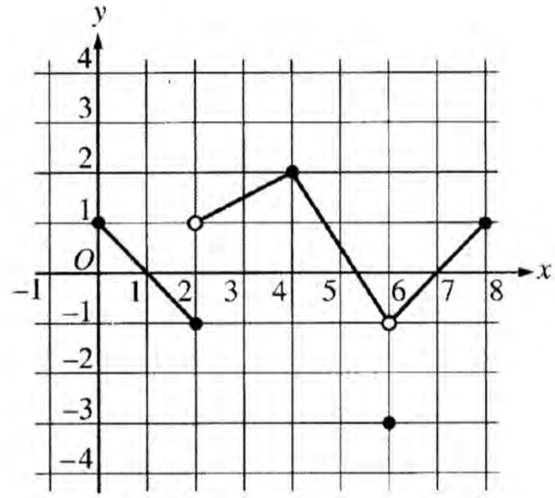
(A) $\frac{1}{8}$ (B) $\frac{1}{4}$ (C) $\frac{1}{2}$ (D) $\frac{3}{4}$ (E) 4

3. If $f(x) = 4x^{-2} + \frac{1}{4}x^2 + 4$, then $f'(2) =$

(A) -62 (B) -58 (C) -3 (D) 0 (E) 1

4. $\int_1^2 \frac{dx}{2x+1} =$

(A) $2\ln 2$ (B) $\frac{1}{2}\ln 2$ (C) $2(\ln 5 - \ln 3)$ (D) $\ln 5 - \ln 3$ (E) $\frac{1}{2}(\ln 5 - \ln 3)$



5. The figure above shows the graph of the function f. Which of the following statements are true?

I. $\lim_{x \to 2^-} f(x) = f(2)$

II. $\lim_{x \to 6^-} f(x) = \lim_{x \to 6^+} f(x)$

III. $\lim_{x \to 6} f(x) = f(6)$

(A) II only

(B) III only

(C) I and II only

(D) II and III only

(E) I, II, and III

6. $\dfrac{d}{dx}\left(\sin^3\left(x^2\right)\right) =$

(A) $\cos^3\left(x^2\right)$

(B) $3\sin^2\left(x^2\right)$

(C) $6x\sin^2\left(x^2\right)$

(D) $3\sin^2\left(x^2\right)\cos\left(x^2\right)$

(E) $6x\sin^2\left(x^2\right)\cos\left(x^2\right)$

7. $\lim_{x \to \infty} \dfrac{x^3}{e^{3x}}$ is

(A) 0 (B) $\dfrac{2}{9}$ (C) $\dfrac{2}{3}$ (D) 1 (E) infinite

8. Using the substitution $u = \sin(2x)$, $\int_{\pi/6}^{\pi/2} \sin^5(2x)\cos(2x)\,dx$ is equivalent to

(A) $-2\int_{1/2}^{1} u^5\,du$

(B) $\frac{1}{2}\int_{1/2}^{1} u^5\,du$

(C) $\frac{1}{2}\int_{0}^{\sqrt{3}/2} u^5\,du$

(D) $\frac{1}{2}\int_{\sqrt{3}/2}^{0} u^5\,du$

(E) $2\int_{\sqrt{3}/2}^{0} u^5\,du$

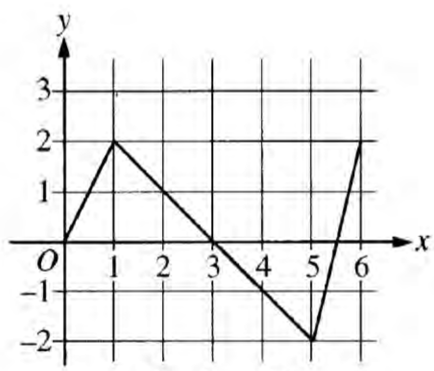
9. The function f has a first derivative given by $f'(x) = x(x-3)^2(x+1)$. At what values of x does f have a relative maximum?

(A) -1 only (B) 0 only (C) -1 and 0 only (D) -1 and 3 only (E) -1, 0, and 3

$$f(x) = \begin{cases} \dfrac{x^2 - 7x + 10}{b(x-2)} & \text{for } x \neq 2 \\ b & \text{for } x = 2 \end{cases}$$

10. Let f be the function defined above. For what value of b is f continuous at $x = 2$?

(A) -3 (B) $\sqrt{2}$ (C) 3 (D) 5 (E) There is no such value of b.



Graph of f'

11. For $0 \leq x \leq 6$, the graph of f', the derivative of f, is piecewise linear as shown above. If $f(0) = 1$, what is the maximum value of f on the interval?

(A) 1 (B) 1.5 (C) 2 (D) 4 (E) 6

12. Let f be the function given by $f(x) = 9^x$. If four subintervals of equal length are used, what is the value of the right Riemann sum approximation for $\int_0^2 f(x)\,dx$?

(A) 20 (B) 40 (C) 60 (D) 80 (E) 120

13. $\dfrac{d}{dx}\left(\dfrac{x+1}{x^2+1}\right) =$

(A) $\dfrac{x^2+2x-1}{\left(x^2+1\right)^2}$

(B) $\dfrac{-x^2-2x+1}{x^2+1}$

(C) $\dfrac{-x^2-2x+1}{\left(x^2+1\right)^2}$

(D) $\dfrac{3x^2+2x+1}{\left(x^2+1\right)^2}$

(E) $\dfrac{1}{2x}$

14. The velocity of a particle moving along the x-axis is given by $v(t) = \sin(2t)$ at time t. If the particle is at $x = 4$ when $t = 0$, what is the position of the particle when $t = \dfrac{\pi}{2}$?

(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

15. The function $y = g(x)$ is differentiable and increasing for all real numbers. On what intervals is the function $y = g\left(x^3 - 6x^2\right)$ increasing?

(A) $(-\infty, 0]$ and $[4, \infty)$ only

(B) $[0, 4]$ only

(C) $[2, \infty)$ only

(D) $[6, \infty)$ only

(E) $(-\infty, \infty)$

16. $\lim_{x \to 3^-} \frac{|x-3|}{x-3}$ is

(A) -3 (B) -1 (C) 1 (D) 3 (E) nonexistent

17. If $f(x) = ae^{-ax}$ for $a > 0$, then $f'(x) =$

(A) e^{-ax}

(B) ae^{-ax}

(C) a^2e^{-ax}

(D) $-ae^{-ax}$

(E) $-a^2e^{-ax}$

18. A student attempted to solve the differential equation $\frac{dy}{dx} = xy$ with initial condition $y = 2$ when $x = 0$. In which step, if any, does an error first appear?

Step 1: $\int \frac{1}{y}\,dy = \int x\,dx$

Step 2: $\ln|y| = \frac{x^2}{2} + C$

Step 3: $|y| = e^{x^2/2} + C$

Step 4: Since $y = 2$ when $x = 0$, $2 = e^0 + C$.

Step 5: $y = e^{x^2/2} + 1$

(A) Step 2

(B) Step 3

(C) Step 4

(D) Step 5

(E) There is no error in the solution.

19. For what values of x does the graph of $y = 3x^5 + 10x^4$ have a point of inflection?

(A) $x = -\frac{8}{3}$ only

(B) $x = -2$ only

(C) $x = 0$ only

(D) $x = 0$ and $x = -\frac{8}{3}$

(E) $x = 0$ and $x = -2$

20. $\lim\limits_{x \to 2} \dfrac{\ln(x+3) - \ln(5)}{x - 2}$ is

(A) 0 (B) $\frac{1}{5}$ (C) $\frac{1}{2}$ (D) 1 (E) nonexistent

21. Functions w, x, and y are differentiable with respect to time and are related by the equation $w = x^2 y$. If x is decreasing at a constant rate of 1 unit per minute and y is increasing at a constant rate of 4 units per minute, at what rate is w changing with respect to time when $x = 6$ and $y = 20$?

(A) -384 (B) -240 (C) -96 (D) 276 (E) 384

22. Let f be the function defined by $f(x) = 2x^3 - 3x^2 - 12x + 18$. On which of the following intervals is the graph of f both decreasing and concave up?

(A) $(-\infty, -1)$ (B) $\left(-1, \frac{1}{2}\right)$ (C) $(-1, 2)$ (D) $\left(\frac{1}{2}, 2\right)$ (E) $(2, \infty)$

$$f(x) = \begin{cases} 3x + 5 & \text{when } x < -1 \\ -x^2 + 3 & \text{when } x \geq -1 \end{cases}$$

23. If f is the function defined above, then $f'(-1)$ is

(A) -3 (B) -2 (C) 2 (D) 3 (E) nonexistent

24. Let f be the function defined by $f(x) = \dfrac{(3x+8)(5-4x)}{(2x+1)^2}$. Which of the following is a horizontal asymptote to the graph of f?

(A) $y = -6$

(B) $y = -3$

(C) $y = -\dfrac{1}{2}$

(D) $y = 0$

(E) $y = \dfrac{3}{2}$

25. If $y = x^2 - 2x$ and $u = 2x + 1$, then $\dfrac{dy}{du} =$

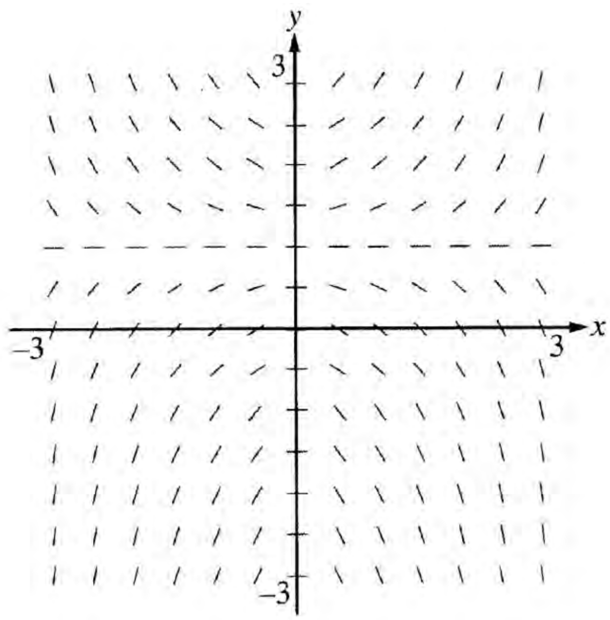
(A) $\dfrac{2(x^2 + x - 1)}{(2x+1)^2}$ (B) $6x^2 - 3x - 2$ (C) $4x$ (D) $x - 1$ (E) $\dfrac{1}{x-1}$

26. For $x > 0$, $\dfrac{d}{dx}\displaystyle\int_1^{\sqrt{x}} \frac{1}{1+t^2}\,dt =$

(A) $\dfrac{1}{2\sqrt{x}(1+x)}$ (B) $\dfrac{1}{2\sqrt{x}(1+\sqrt{x})}$ (C) $\dfrac{1}{1+x}$ (D) $\dfrac{\sqrt{x}}{1+x}$ (E) $\dfrac{1}{1+\sqrt{x}}$

27. A particle moves on the x-axis so that at any time t, $0 \le t \le 1$, its position is given by $x(t) = \sin(2\pi t) + 2\pi t$. For what value of t is the particle at rest?

(A) 0 (B) $\frac{1}{8}$ (C) $\frac{1}{4}$ (D) $\frac{1}{2}$ (E) 1



28. Shown above is a slope field for which of the following differential equations?

(A) $\frac{dy}{dx} = xy - x$

(B) $\frac{dy}{dx} = xy + x$

(C) $\frac{dy}{dx} = y - x^2$

(D) $\frac{dy}{dx} = (y - 1)x^2$

(E) $\frac{dy}{dx} = (y - 1)^3$

CALCULUS AB
SECTION I, Part B
Time—50 minutes
Number of questions—17

A GRAPHING CALCULATOR IS REQUIRED FOR SOME QUESTIONS ON THIS PART OF THE EXAM.

29. A particle moves along a straight line so that at time $t > 0$ the position of the particle is given by $s(t)$, the velocity is given by $v(t)$, and the acceleration is given by $a(t)$. Which of the following expressions gives the average velocity of the particle on the interval $[2, 8]$?

(A) $\frac{1}{6}\int_2^8 a(t)\,dt$

(B) $\frac{1}{6}\int_2^8 s(t)\,dt$

(C) $\frac{s(8)-s(2)}{6}$

(D) $\frac{v(8)-v(2)}{6}$

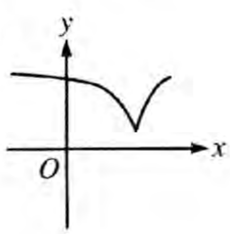
(E) $v(8)-v(2)$

30. If $\sin\left(\frac{1}{x^2+1}\right)$ is an antiderivative for $f(x)$, then $\int_1^2 f(x)\,dx =$

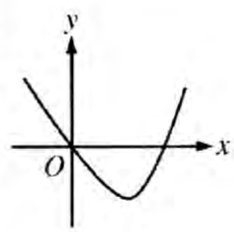
(A) -0.281 (B) -0.102 (C) 0.102 (D) 0.260 (E) 0.282

31. The function f is differentiable and increasing for all real numbers x, and the graph of f has exactly one point of inflection. Of the following, which could be the graph of f', the derivative of f?

(A)



(B)



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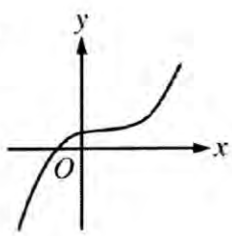

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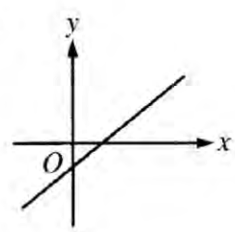
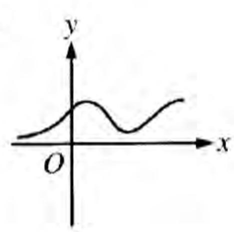


(E)



32. A vase has the shape obtained by revolving the curve $y = 2 + \sin x$ from $x = 0$ to $x = 5$ about the x-axis, where x and y are measured in inches. What is the volume, in cubic inches, of the vase?

(A) 10.716 (B) 25.501 (C) 33.666 (D) 71.113 (E) 80.115

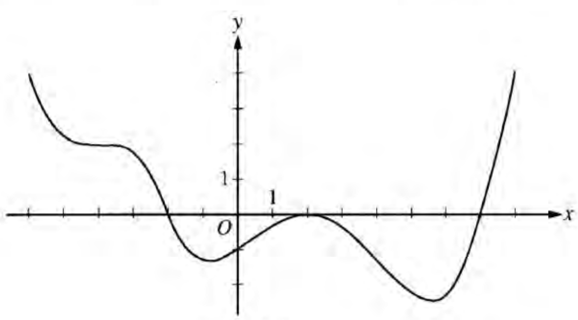
x	$f(x)$
1	2.4
3	3.6
5	5.4

33. The table above gives selected values of a function f. The function is twice differentiable with $f''(x) > 0$. Which of the following could be the value of $f'(3)$?

(A) 0.6 (B) 0.7 (C) 0.9 (D) 1.2 (E) 1.5

34. At time $t = 0$ years, a forest preserve has a population of 1500 deer. If the rate of growth of the population is modeled by $R(t) = 2000e^{0.23t}$ deer per year, what is the population at time $t = 3$?

(A) 3987 (B) 5487 (C) 8641 (D) 10,141 (E) 12,628



Graph of f'

35. The figure above shows the graph of f', the derivative of function f, for $-6 < x < 8$. Of the following, which best describes the graph of f on the same interval?

(A) 1 relative minimum, 1 relative maximum, and 3 points of inflection

(B) 1 relative minimum, 1 relative maximum, and 4 points of inflection

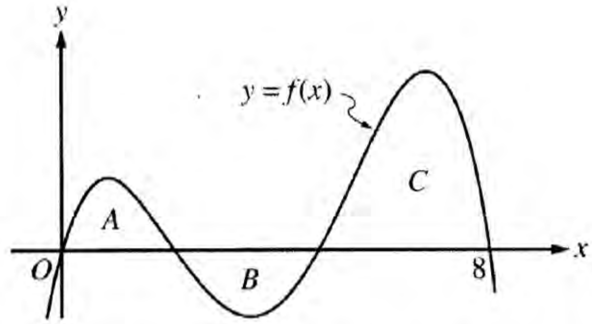
(C) 2 relative minima, 1 relative maximum, and 2 points of inflection

(D) 2 relative minima, 1 relative maximum, and 4 points of inflection

(E) 2 relative minima, 2 relative maxima, and 3 points of inflection

36. Let f and g be continuous functions such that $\int_0^6 f(x)\,dx = 9$, $\int_3^6 f(x)\,dx = 5$, and $\int_3^0 g(x)\,dx = -7$. What is the value of $\int_0^3 \left(\frac{1}{2}f(x) - 3g(x)\right) dx$?

(A) -23 (B) -19 (C) $-\frac{17}{2}$ (D) 19 (E) 23



37. The regions A, B, and C in the figure above are bounded by the graph of the function f and the x-axis. The area of region A is 14, the area of region B is 16, and the area of region C is 50. What is the average value of f on the interval $[0, 8]$?

(A) 6 (B) 10 (C) $\frac{40}{3}$ (D) $\frac{80}{3}$ (E) 48

38. A particle moves along the x-axis so that its velocity at time $t \geq 0$ is given by $v(t) = \frac{t^2 - 1}{t^2 + 1}$. What is the total distance traveled by the particle from $t = 0$ to $t = 2$?

(A) 0.214 (B) 0.320 (C) 0.600 (D) 0.927 (E) 1.600

39. Line ℓ is tangent to the graph of $y = e^x$ at the point (k, e^k). What is the positive value of k for which the y-intercept of ℓ is $\frac{1}{2}$?

(A) 0.405
(B) 0.768
(C) 1.500
(D) 1.560
(E) There is no such value of k.

40. A differentiable function f has the property that $f'(x) \le 3$ for $1 \le x \le 8$ and $f(5) = 6$. Which of the following could be true?

I. $f(2) = 0$

II. $f(6) = -2$

III. $f(7) = 13$

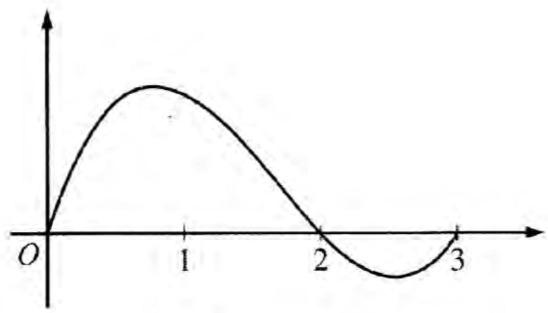
(A) I only

(B) II only

(C) I and II only

(D) I and III only

(E) II and III only



Graph of f

41. The graph of the differentiable function f is shown in the figure above. Let h be the function defined by $h(x) = \int_0^x f(t)\,dt$. Which of the following correctly orders $h(2)$, $h'(2)$, and $h''(2)$?

(A) $h(2) < h'(2) < h''(2)$

(B) $h'(2) < h(2) < h''(2)$

(C) $h'(2) < h''(2) < h(2)$

(D) $h''(2) < h(2) < h'(2)$

(E) $h''(2) < h'(2) < h(2)$

42. What is the area of the region enclosed by the graphs of $y = e^x - 2$, $y = \sin x$, and $x = 0$?

(A) 0.239 (B) 0.506 (C) 0.745 (D) 2.340 (E) 3.472

43. A particle moves along a line so that its velocity is given by $v(t) = -t^3 + 2t^2 + 2^{-t}$ for $t \geq 0$. For what values of t is the speed of the particle increasing?

(A) $(0, 0.177)$ and $(1.256, \infty)$

(B) $(0, 1.256)$ only

(C) $(0, 2.057)$ only

(D) $(0.177, 1.256)$ only

(E) $(0.177, 1.256)$ and $(2.057, \infty)$

44. Let F be a function defined for all real numbers x such that $F'(x) > 0$ and $F''(x) > 0$. Which of the follow could be a table of values for F ?

(A)

x	$F(x)$
1	−3
2	−4
3	−6
4	−9

(B)

x	$F(x)$
1	−3
2	−1
3	3
4	19

(C)

x	$F(x)$
1	−3
2	0
3	3
4	6

(D)

x	$F(x)$
1	−3
2	5
3	11
4	13

(E)

x	$F(x)$
1	−3
2	−4
3	−3
4	0

x	$f(x)$	$g(x)$	$f'(x)$
−4	0	−9	5
−2	4	−7	4
0	6	−4	2
2	7	−3	1
4	10	−2	3

45. The table above gives values of the differentiable functions f and g, and f', the derivative of f, at selected values of x. If $g(x) = f^{-1}(x)$, what is the value of $g'(4)$?

(A) $-\frac{1}{3}$ (B $-\frac{1}{4}$ (C) $-\frac{3}{100}$ (D $\frac{1}{4}$ (E) $\frac{1}{3}$

CALCULUS AB
SECTION II, Part A
Time—30 minutes
Number of problems—2

Name ___________________

Periods _____

A graphing calculator is required for these problems.

t (hours)	0	0.4	0.8	1.2	1.6	2.0	2.4
$v(t)$ (miles per hour)	0	11.8	9.5	17.2	16.3	16.8	20.1

1. Ruth rode her bicycle on a straight trail. She recorded her velocity $v(t)$, in miles per hour, for selected values of t over the interval $0 \le t \le 2.4$ hours, as shown in the table above. For $0 < t \le 2.4$, $v(t) > 0$.

(a) Use the data in the table to approximate Ruth's acceleration at time $t = 1.4$ hours. Show the computations that lead to your answer. Indicate units of measure.

(b) Using correct units, interpret the meaning of $\int_0^{2.4} v(t)\,dt$ in the context of the problem. Approximate $\int_0^{2.4} v(t)\,dt$ using a midpoint Riemann sum with three subintervals of equal length and values from the table.

(c) For $0 \le t \le 2.4$ hours, Ruth's velocity can be modeled by the function g given by $g(t) = \dfrac{24t + 5\sin(6t)}{t + 0.7}$. According to the model, what was Ruth's average velocity during the time interval $0 \le t \le 2.4$?

(d) According to the model given in part (c), is Ruth's speed increasing or decreasing at time $t = 1.3$? Give a reason for your answer.

2. A store is having a 12-hour sale. The total number of shoppers who have entered the store t hours after the sale begins is modeled by the function S defined by $S(t) = 0.5t^4 - 16t^3 + 144t^2$ for $0 \le t \le 12$. At time $t = 0$, when the sale begins, there are no shoppers in the store.

(a) At what rate are shoppers entering the store 3 hours after the start of the sale?

(b) Find the value of $\frac{1}{3}\int_6^9 S'(t)\,dt$. Using correct units, explain the meaning of $\frac{1}{3}\int_6^9 S'(t)\,dt$ in the context of this problem.

(c) The rate at which shoppers leave the store, measured in shoppers per hour, is modeled by the function L defined by $L(t) = -80 + \dfrac{4400}{t^2 - 14t + 55}$ for $0 \le t \le 12$. According to the model, how many shoppers are in the store at the end of the sale (time $t = 12$)? Give your answer to the nearest whole number.

(d) Using the given models, find the time t, $0 \le t \le 12$, at which the number of shoppers in the store is the greatest. Justify your answer.

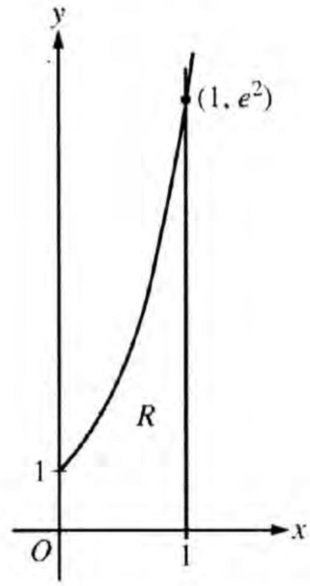
END OF PART A OF SECTION II

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON PART A ONLY. DO NOT GO ON TO PART B UNTIL YOU ARE TOLD TO DO SO.

CALCULUS AB
SECTION II, Part B

Time—60 minutes
Number of problems—4

No calculator is allowed for these problems.

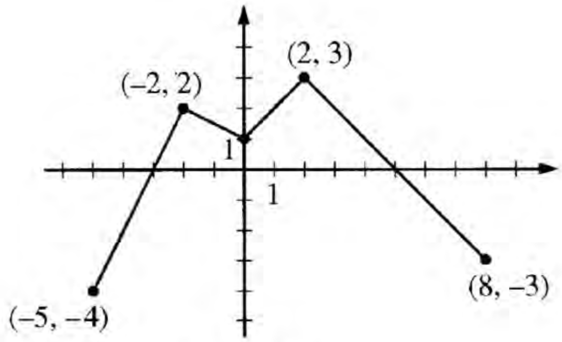


3. Let $f(x) = e^{2x}$. Let R be the region in the first quadrant bounded by the graph of $y = f(x)$ and the vertical line $x = 1$, as shown in the figure above.

   (a) Write an equation for the line tangent to the graph of f at $x = 1$.

   (b) Find the area of R.

   (c) Region R forms the base of a solid whose cross sections perpendicular to the y-axis are squares. Write, but do not evaluate, an expression involving one or more integrals that gives the volume of the solid.



Graph of f

4. The continuous function f is defined on the interval $-5 \le x \le 8$. The graph of f, which consists of four line segments, is shown in the figure above. Let g be the function given by $g(x) = 2x + \int_{-2}^{x} f(t)\,dt$.

(a) Find $g(0)$ and $g(-5)$.

(b) Find $g'(x)$ in terms of $f(x)$. For each of $g''(4)$ and $g''(-2)$, find the value or state that it does not exist.

(c) On what intervals, if any, is the graph of g concave down? Give a reason for your answer.

(d) The function h is given by $h(x) = g\left(x^3 + 1\right)$. Find $h'(1)$. Show the work that leads to your answer.

5. Particle X moves along the positive x-axis so that its position at time $t \geq 0$ is given by $x(t) = 5t^3 - 9t^2 + 7$.

(a) Is particle X moving toward the left or toward the right at time $t = 1$? Give a reason for your answer.

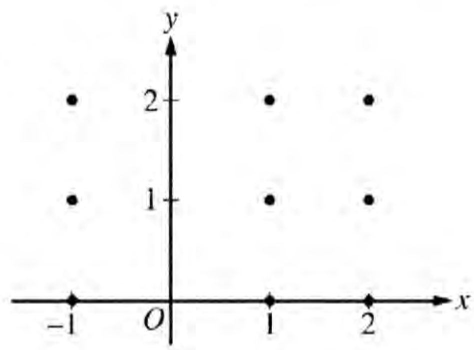
(b) At what time $t \geq 0$ is particle X farthest to the left? Justify your answer.

(c) A second particle, Y, moves along the positive y-axis so that its position at time t is given by $y(t) = 7t + 3$. At any time t, $t \geq 0$, the origin and the positions of the particles X and Y are the vertices of a triangle in the first quadrant. Find the rate of change of the area of the triangle at time $t = 1$. Show the work that leads to your answer.

6. Consider the differential equation $\frac{dy}{dx} = \left(1 - \frac{2}{x^2}\right)(y - 1)$, where $x \neq 0$. Let $y = f(x)$ be the particular solution to the differential equation with initial condition $f(1) = 2$.

(a) Find the slope of the line tangent to the graph of f at the point $(1, 2)$.

(b) On the axes provided, sketch a slope field for the given differential equation at the nine points indicated.



(c) Find the particular solution $y = f(x)$ to the differential equation $\frac{dy}{dx} = \left(1 - \frac{2}{x^2}\right)(y - 1)$ with initial condition $f(1) = 2$.

Answer Key for AP Calculus AB Practice Exam, Section I

Question 1: A

Question 2: B

Question 3: D

Question 4: E

Question 5: C

Question 6: E

Question 7: A

Question 8: D

Question 9: A

Question 10: E

Question 11: D

Question 12: C

Question 13: C

Question 14: D

Question 15: A

Question 16: B

Question 17: E

Question 18: B

Question 19: B

Question 20: B

Question 21: C

Question 22: D

Question 23: E

Question 24: B

Question 25: D

Question 26: A

Question 27: D

Question 28: A

Question 29 C

Question 30 A

Question 31 A

Question 32 E

Question 33 B

Question 34 D

Question 35 A

Question 36 B

Question 37 A

Question 38 D

Question 39 B

Question 40 C

Question 41 E

Question 42 C

Question 43 E

Question 44 B

Question 45 D

2014 AB Mult. Choice Solutions

1. $\left(t^3 - t\right)\Big|_2^x$

$(x^3 - x) - (8 - 2)$

$x^3 - x - 6$

$\boxed{A}$

2. $y' = \frac{2}{2x}$

$= \frac{1}{x}$

$y'\Big|_{x=4} = \frac{1}{4}$

$\boxed{B}$

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

$f'(2) = \frac{-8}{8} + \frac{1}{2}\cdot 2$

$= 0$

$\boxed{D}$

4. $\frac{1}{2}\int_1^2 \frac{2}{2x+1}\,dx$

$\frac{1}{2}\ln|2x+1|\,\Big|_1^2$

$\frac{1}{2}\ln 5 - \frac{1}{2}\ln 3$

$\boxed{E}$

5. I. $\lim_{x\to 2^-} f(x) = -1$ True

$f(2) = -1$

II. $\lim_{x\to 6^-} f(x) = -1$ True

$\lim_{x\to 6^+} f(x) = -1$

III. $\lim_{x\to 6} f(x) = -1$ False

$f(6) = -3$

$\boxed{C}$

6. $\frac{d}{dx}\left(\sin x^2\right)^3 = 3\left(\sin x^2\right)^2 \cdot \cos x^2 \cdot 2x$

$= 6x\sin^2(x^2)\cos(x^2)$

$\boxed{E}$

7. Method 1

$\lim_{x\to\infty} \frac{x^3}{e^{3x}} = \lim_{x\to\infty} \frac{3x^2}{3e^{3x}}$

$= \lim_{x\to\infty} \frac{6x}{9e^{3x}}$

$= \lim_{x\to\infty} \frac{6}{27e^{3x}}$

$= 0$

$\frac{\infty}{\infty}$ using L'Hopital's (3 times)

$\boxed{A}$

Method 2

$\lim_{x\to\infty} \frac{x^3}{e^{3x}} = 0$ because exponentials have a faster growth rate than cubics

8. $u = \sin(2x)$

$du = 2\cos(2x)\,dx$

$x = \frac{\pi}{2} \to u = 0$

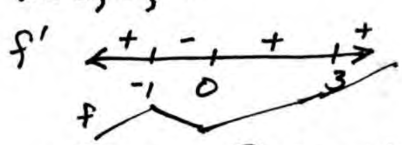
$x = \frac{\pi}{6} \to u = \frac{\sqrt{3}}{2}$

$\int_{\pi/6}^{\pi/2} \left(\sin(2x)\right)^5 \cos(2x)\,dx =$

$\frac{1}{2}\int_{\sqrt{3}/2}^{0} u^5\,du$ $\boxed{D}$

9. CN

$x = 0, 3, -1$



rel. max @ $x = -1$

$\boxed{A}$

2014 AB Mult. Ch. Solutions (continued)

10. $\dfrac{(x-5)(x-2)}{b(x-2)} = \dfrac{x-5}{b}, \; x \neq 2$

$\dfrac{x-5}{b} = b$ when $x=2$

$\dfrac{-3}{b} = b$

$-3 = b^2$

not possible

$\boxed{E}$

11. CN $x = 0, 3, 5.5$ (Candidate Test)

$f(0) = 1$

$f(3) = 1 + \frac{1}{2}\cdot 3 \cdot 2 = 4$

$f(5.5) = 4 - \frac{1}{2}\cdot\frac{5}{2}\cdot 2 = 1.5$

$f(6) = 1.5 + \frac{1}{2}\cdot\frac{1}{2}\cdot 2 = 2$

$\max f = 4$

$\boxed{D}$

12. $\frac{1}{2}\left(9^{\frac{1}{2}} + 9^{1} + 9^{\frac{3}{2}} + 9^{2}\right)$

$\frac{1}{2}\left(3 + 9 + 27 + 81\right)$

60

$\boxed{C}$

13. $\dfrac{d}{dx}\left(\dfrac{x+1}{x^2+1}\right) = \dfrac{(x^2+1)\cdot 1 - (x+1)\cdot 2x}{(x^2+1)^2}$

$= \dfrac{x^2+1-2x^2-2x}{(x^2+1)^2}$

$= \dfrac{-x^2-2x+1}{(x^2+1)^2}$

$\boxed{C}$

14. $x\left(\frac{\pi}{2}\right) = 4 + \frac{1}{2}\int_0^{\frac{\pi}{2}} 2\cdot\sin(2t)\,dt$

$= 4 - \frac{1}{2}\cos(2t)\Big|_0^{\frac{\pi}{2}}$

$= 4 - \left(\frac{1}{2}\cos\pi - \frac{1}{2}\cos 0\right)$

$= 4 - \left(-\frac{1}{2} - \frac{1}{2}\right)$

$= 5$ $\boxed{D}$

15. $y' = g'(x^3-6x^2)(3x^2-12x)$

since g is incr., $g'(x) \geq 0$

$3x^2 - 12x \geq 0$

$3x(x-4) \geq 0$ CN $x = 0, 4$

y': $+$ (0) $-$ (4) $+$

$\boxed{A}$

16. $\dfrac{\text{positive}}{\text{negative}}$ $\boxed{B}$

17. $f(x) = a e^{-ax}$

$f'(x) = a e^{-ax}\cdot(-a)$

$= -a^2 e^{-ax}$

$\boxed{E}$

18. Step 3 should be

$|y| = C_1 e^{\frac{x^2}{2}}$ or $|y| = e^{\frac{x^2}{2}+C}$

$\boxed{B}$

19. $y' = 15x^4 + 40x^3$

$y'' = 60x^3 + 120x^2$

$0 = 60x^2(x+2)$

$x = 0, -2$ y'': $-$ (−2) $+$ (0) $+$

$\boxed{B}$

2014 AB Mult. Ch. Solutions (continued)

20. Method 1

$$\lim_{x \to 2} \frac{\ln(x+3) - \ln 5}{x-2}$$ $\frac{0}{0}$ form (use L'Hp.)

$$\lim_{x \to 2} \frac{\frac{1}{x+3} - 0}{1}$$

$$\frac{1}{5}$$ $\boxed{B}$

Method 2

This is the limit def. of the derivitive (alt. form) when $f(x) = \ln(x+3)$ @ $x = 2$.

$f'(x) = \frac{1}{x+3}$

$f'(2) = \frac{1}{5}$

21. $W = x^2 y$ $\quad \frac{dx}{dt} = -1$

$\frac{dy}{dt} = 4$

$$\frac{dw}{dt} = x^2 \cdot \frac{dy}{dt} + y \cdot 2x \frac{dx}{dt}$$

$= 36 \cdot 4 + 20 \cdot 2 \cdot 6(-1)$

$= 144 - 240$

$= -96$ $\boxed{C}$

22. $f'(x) = 6x^2 - 6x - 12$

$= 6(x^2 - x - 2)$

$= 6(x-2)(x+1)$

f': $+$ | -1 | $-$ | 2 | $+$

$f''(x) = 12x - 6$

f'': $-$ | $\frac{1}{2}$ | $+$ $\boxed{D}$

f is dec., ccu on $(\frac{1}{2}, 2)$

23. f is cont. @ $x = -1$

$$f'(x) = \begin{cases} 3, & x < -1 \\ -2x, & x > -1 \end{cases}$$

$f'(-1)$ does not exist

f has a sharp turn @ $x = -1$

$\boxed{E}$

24. $\lim_{x \to \infty} f(x) = \lim_{x \to \infty} \frac{-12x^2}{4x^2}$

$= -3$

H.A. @ $y = -3$

$\boxed{B}$

2014 AB Mult. Ch. (continued)

25. Method 1

$y = x^2 - 2x$ $\qquad u = 2x+1$

$\frac{dy}{du} = 2x\frac{dx}{du} - 2\frac{dx}{du}$ $\qquad \frac{du}{du} = 2\frac{dx}{du}$

$\frac{1}{2} = \frac{dx}{du}$

$\frac{dy}{du} = 2x \cdot \frac{1}{2} - 2 \cdot \frac{1}{2}$

$= x - 1$ $\boxed{D}$

Method 2

$u = 2x+1$

$\frac{1}{2}u - \frac{1}{2} = x$

$y = x^2 - 2x$

$y = (\frac{1}{2}u - \frac{1}{2})^2 - 2(\frac{1}{2}u - \frac{1}{2})$

$y = \frac{1}{4}u^2 - \frac{1}{2}u + \frac{1}{4} - u + 1$

$\frac{dy}{du} = \frac{1}{2}u - \frac{1}{2} - 1$

$\frac{dy}{du} = \frac{1}{2}(2x+1) - \frac{3}{2}$

$= x + \frac{1}{2} - \frac{3}{2}$

$= x - 1$

Method 3 (parametric)

$y = x^2 - 2x$ $\qquad u = 2x+1$

$\frac{dy}{dx} = 2x - 2$ $\qquad \frac{du}{dx} = 2$

$\frac{dy}{du} = \frac{\frac{dy}{dx}}{\frac{du}{dx}}$

$= \frac{2x-2}{2}$

$= x - 1$

(Method 3 is essentially the same as Method 1.)

26. $\frac{d}{dx}\int_1^{\sqrt{x}} \frac{1}{1+t^2}\,dt =$

$\frac{1}{1+(\sqrt{x})^2} \cdot \frac{1}{2}x^{-\frac{1}{2}} =$

$\frac{1}{2\sqrt{x}(1+x)}$ $\boxed{A}$

27. $v(t) = 2\pi\cos(2\pi t) + 2\pi$

$0 = 2\pi(\cos(2\pi t) + 1)$

$\cos(2\pi t) = -1$

$2\pi t = \pi, 3\pi, \ldots$

$t = \frac{1}{2}, \cancel{\frac{3}{2}, \ldots}$

$\boxed{D}$

28. $\frac{dy}{dx}$ is zero when $y = 1$ and when $x = 0$.

$\frac{dy}{dx}$ is negative when $x < 0$ and $y > 1$.

This works for $\frac{dy}{dx} = xy - x$
$= x(y-1)$

$\boxed{A}$

29. Avg. vel. is AROC of position.

$v_{avg} = \frac{s(8) - s(2)}{8-2}$

$\boxed{C}$

2014 AB Mult. Ch. (continued)

30. $\int_1^2 f(x)\,dx =$

$\sin\left(\frac{1}{x^2+1}\right)\Big|_1^2$

$\sin\frac{1}{5} - \sin\frac{1}{2}$

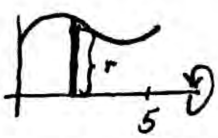
$-.281$ $\boxed{A}$

31. f is increasing $\rightarrow f' \geq 0$

f has one POI $\rightarrow f'$ has one rel. max./min.

only $\boxed{A}$ fits

32.



disc method

$V = \pi \int_0^5 (2+\sin x)^2\,dx$

$= 80.115$ $\boxed{E}$

33. $f''(x) > 0 \rightarrow f'$ is increasing

AROC on $[1,3] < f'(3) <$ AROC on $[3,5]$

$\frac{3.6-2.4}{2} < f'(3) < \frac{5.4-3.6}{2}$

$.6 < f'(3) < .9$

$\boxed{B}$

34. $Pop(3) = 1500 + \int_0^3 2000e^{.23t}\,dt$

$= 10141$

$\boxed{D}$

35. f': $+$ | -2 | $-$ | 2 | $-$ | 7 | $+$

f'': $-$ | -1 | $+$ | 2 | $-$ | ~ 5.5 | $+$

3 POI

$\boxed{A}$

36. $\int_0^3 f(x)\,dx = 9-5$
$= 4$

$\int_0^3 g(x)\,dx = -(-7)$
$= 7$

$\frac{1}{2}\int_0^3 f(x)\,dx - 3\int_0^3 g(x)\,dx$

$\frac{1}{2}(4) - 3(7)$

-19

$\boxed{B}$

37. $f_{avg} = \frac{\int_0^8 f(x)\,dx}{8}$

$= \frac{14-16+50}{8}$

$= 6$ $\boxed{A}$

2014 AB Mult. Ch. (continued)

38. $TD = \int_0^2 \left| \frac{t^2-1}{t^2+1} \right| dt$

$= .927$ $\boxed{D}$

39. $y' = e^x$

$y'(k) = e^k$

Tan. line:

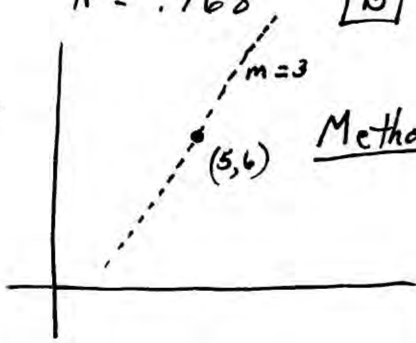
$y - e^k = e^k(x-k)$

$y = e^k(x-k) + e^k$

y-int. point $(0, \frac{1}{2})$

$\frac{1}{2} = e^k(-k) + e^k$

$k = .768$ $\boxed{B}$

40. 

Method 1

$f(7) \le 6 + 3 \cdot 2 = 12$

$f(2) \ge 6 - 3 \cdot 3 = -3$

$f(6) \le 6 + 3 \cdot 1 = 9$

only I and II are true

$\boxed{C}$

Method 2

I $f(2) = 0 \rightarrow AROC = \frac{6-0}{5-2} = 2 < 3$

II $f(6) = -2 \rightarrow AROC = \frac{6+2}{5-6} = -8 < 3$

III $f(7) = 13 \rightarrow AROC = \frac{6-13}{5-7} = 3.5 \not< 3$

III is not possible by MVT

41. $h(2) = \int_0^2 f(t)\,dt > 0$

$h'(x) = f(x)$

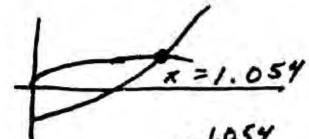
$h'(2) = f(2) = 0$

$h''(x) = f'(x)$

$h''(2) = f'(2) < 0$

order: $h''(2) < h'(2) < h(2)$

$\boxed{E}$

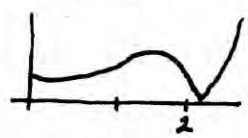
42. 

$Area = \int_0^{1.054} (\sin x - (e^x - 2))\,dx$

$= .745$ $\boxed{C}$

43. Method 1

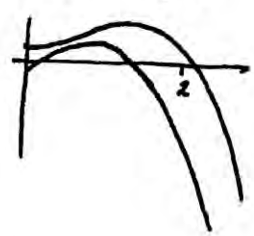
graph speed $= |-t^3 + 2t^2 + 2^{-t}|$
and look for positive slopes



$\boxed{E}$

Method 2

graph $v(t)$ and its derivative and look for the same sign



2014 AB Mult. Ch. (continued)

44. F must be increasing at an increasing rate

A is decr.

$\boxed{B}$ is incr. at an incr. rate

C is incr. at a const. rate

D is incr. at a decr. rate

E is oscillating

45. f $g = f^{-1}$

$(-2, 4)$ $(4, -2)$

$m = 4$ $m = \frac{1}{4}$

$\boxed{D}$

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Question 1

t (hours)	0	0.4	0.8	1.2	1.6	2.0	2.4
$v(t)$ (miles per hour)	0	11.8	9.5	17.2	16.3	16.8	20.1

Ruth rode her bicycle on a straight trail. She recorded her velocity $v(t)$, in miles per hour, for selected values of t over the interval $0 \le t \le 2.4$ hours, as shown in the table above. For $0 < t \le 2.4$, $v(t) > 0$.

(a) Use the data in the table to approximate Ruth's acceleration at time $t = 1.4$ hours. Show the computations that lead to your answer. Indicate units of measure.

(b) Using correct units, interpret the meaning of $\int_0^{2.4} v(t)\,dt$ in the context of the problem. Approximate $\int_0^{2.4} v(t)\,dt$ using a midpoint Riemann sum with three subintervals of equal length and values from the table.

(c) For $0 \le t \le 2.4$ hours, Ruth's velocity can be modeled by the function g given by $g(t) = \dfrac{24t + 5\sin(6t)}{t + 0.7}$. According to the model, what was Ruth's average velocity during the time interval $0 \le t \le 2.4$?

(d) According to the model given in part (c), is Ruth's speed increasing or decreasing at time $t = 1.3$? Give a reason for your answer.

(a) $a(1.4) \approx \dfrac{v(1.6) - v(1.2)}{1.6 - 1.2} = \dfrac{16.3 - 17.2}{1.6 - 1.2} = -2.25 \text{ miles/hr}^2$

$2 : \begin{cases} 1 : \text{approximation} \\ 1 : \text{units} \end{cases}$

(b) $\int_0^{2.4} v(t)\,dt$ is the total distance Ruth traveled, in miles, from time $t = 0$ to time $t = 2.4$ hours.

$$\int_0^{2.4} v(t)\,dt \approx (0.8)(11.8) + (0.8)(17.2) + (0.8)(16.8) = 36.64 \text{ miles}$$

$3 : \begin{cases} 1 : \text{interpretation} \\ 1 : \text{midpoint Riemann sum} \\ 1 : \text{approximation} \end{cases}$

(c) Average velocity $= \dfrac{1}{2.4}\int_0^{2.4} g(t)\,dt = 14.064$ miles/hr

$2 : \begin{cases} 1 : \text{integral} \\ 1 : \text{answer} \end{cases}$

(d) Velocity $= g(1.3) = 18.096358 > 0$
Acceleration $= g'(1.3) = 3.761152 > 0$

Ruth's speed is increasing at time $t = 1.3$ since velocity and acceleration have the same sign at this time.

2 : conclusion with reason

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Question 2

A store is having a 12-hour sale. The total number of shoppers who have entered the store t hours after the sale begins is modeled by the function S defined by $S(t) = 0.5t^4 - 16t^3 + 144t^2$ for $0 \le t \le 12$. At time $t = 0$, when the sale begins, there are no shoppers in the store.

(a) At what rate are shoppers entering the store 3 hours after the start of the sale?

(b) Find the value of $\frac{1}{3}\int_6^9 S'(t)\,dt$. Using correct units, explain the meaning of $\frac{1}{3}\int_6^9 S'(t)\,dt$ in the context of this problem.

(c) The rate at which shoppers leave the store, measured in shoppers per hour, is modeled by the function L defined by $L(t) = -80 + \dfrac{4400}{t^2 - 14t + 55}$ for $0 \le t \le 12$. According to the model, how many shoppers are in the store at the end of the sale (time $t = 12$)? Give your answer to the nearest whole number.

(d) Using the given models, find the time t, $0 \le t \le 12$, at which the number of shoppers in the store is the greatest. Justify your answer.

(a) $S'(3) = 486$ shoppers/hour

1 : answer

(b) $\frac{1}{3}\int_6^9 S'(t)\,dt = \frac{1}{3}(S(9) - S(6))$

$= \frac{1}{3}(3280.5 - 2376) = 301.5$

$\frac{1}{3}\int_6^9 S'(t)\,dt$ is the average rate at which shoppers are entering the store in shoppers/hr between times $t = 6$ and $t = 9$ hours.

$2 : \begin{cases} 1 : \text{value of } \frac{1}{3}\int_6^9 S'(t)\,dt \\ 1 : \text{meaning of } \frac{1}{3}\int_6^9 S'(t)\,dt \end{cases}$

(c) $S(12) - \int_0^{12} L(t)\,dt = 195.701684$

Therefore, there are approximately 196 shoppers in the store at the end of the sale.

$3 : \begin{cases} 1 : \text{integral} \\ 1 : \text{uses } S(12) \\ 1 : \text{answer} \end{cases}$

(d) The number of shoppers in the store at time t is given by the function N defined by

$N(t) = S(t) - \int_0^t L(x)\,dx$

$N'(t) = S'(t) - L(t) = 0$ when $t = 5.545066$

t	$N(t)$
0	0
5.545066	1361.832842
12	195.702

The number of shoppers in the store is greatest at time $t = 5.545$ hours.

$3 : \begin{cases} 1 : \text{considers } S'(t) - L(t) = 0 \\ 1 : \text{answer} \\ 1 : \text{justification} \end{cases}$

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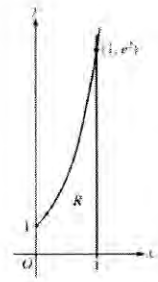
Question 3



Let $f(x) = e^{2x}$. Let R be the region in the first quadrant bounded by the graph of $y = f(x)$ and the vertical line $x = 1$, as shown in the figure above.

(a) Write an equation for the line tangent to the graph of f at $x = 1$.

(b) Find the area of R.

(c) Region R forms the base of a solid whose cross sections perpendicular to the y-axis are squares. Write, but do not evaluate, an expression involving one or more integrals that gives the volume of the solid.

(a) $f(1) = e^2$

$f'(x) = 2e^{2x} \Rightarrow f'(1) = 2e^2$

An equation for the tangent line is $y = e^2 + 2e^2(x - 1)$.

$2 : \begin{cases} 1 : f'(1) \\ 1 : \text{answer} \end{cases}$

(b) $\text{Area} = \int_0^1 e^{2x}\,dx = \left[\frac{1}{2}e^{2x}\right]_{x=0}^{x=1} = \frac{1}{2}\left(e^2 - 1\right)$

$3 : \begin{cases} 1 : \text{integral} \\ 1 : \text{antiderivative} \\ 1 : \text{answer} \end{cases}$

(c) $\text{Volume} = 1 + \int_1^{e^2} \left(1 - \frac{1}{2}\ln y\right)^2 dy$

$4 : \begin{cases} 2 : \text{integrand} \\ 1 : \text{limits} \\ 1 : \text{answer} \end{cases}$

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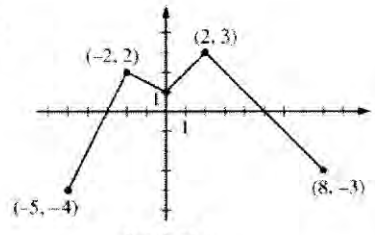
Question 4

The continuous function f is defined on the interval $-5 \le x \le 8$. The graph of f, which consists of four line segments, is shown in the figure above.



Graph of f

Let g be the function given by $g(x) = 2x + \int_{-2}^{x} f(t)\,dt$.

(a) Find $g(0)$ and $g(-5)$.

(b) Find $g'(x)$ in terms of $f(x)$. For each of $g''(4)$ and $g''(-2)$, find the value or state that it does not exist.

(c) On what intervals, if any, is the graph of g concave down? Give a reason for your answer.

(d) The function h is given by $h(x) = g\left(x^3 + 1\right)$. Find $h'(1)$. Show the work that leads to your answer.

(a) $g(0) = 2 \cdot 0 + \int_{-2}^{0} f(t)\,dt = 3$

$g(-5) = 2 \cdot (-5) + \int_{-2}^{-5} f(t)\,dt = -10 + 3 = -7$

$2 : \begin{cases} 1 : g(0) \\ 1 : g(-5) \end{cases}$

(b) $g'(x) = 2 + f(x)$
$g''(x) = f'(x)$

$g''(4) = f'(4) = -1$

$g''(-2) = f'(-2)$ does not exist.

$3 : \begin{cases} 1 : g'(x) \\ 1 : g''(4) \\ 1 : g''(-2) \text{ does not exist} \end{cases}$

(c) The graph of g is concave down on the intervals $(-2, 0)$ and $(2, 8)$ since $g'(x) = 2 + f(x)$ decreases on those intervals.

1 : intervals and reason

(d) $h'(x) = g'\left(x^3 + 1\right) \cdot 3x^2$

$h'(1) = g'(2) \cdot 3 = (2 + f(2)) \cdot 3$
$= (2 + 3) \cdot 3 = 15$

$3 : \begin{cases} 2 : \text{chain rule} \\ 1 : \text{answer} \end{cases}$

Question 5

Particle X moves along the positive x-axis so that its position at time $t \ge 0$ is given by $x(t) = 5t^3 - 9t^2 + 7$.

(a) Is particle X moving toward the left or toward the right at time $t = 1$? Give a reason for your answer.

(b) At what time $t \ge 0$ is particle X farthest to the left? Justify your answer.

(c) A second particle, Y, moves along the positive y-axis so that its position at time t is given by $y(t) = 7t + 3$. At any time t, $t \ge 0$, the origin and the positions of the particles X and Y are the vertices of a triangle in the first quadrant. Find the rate of change of the area of the triangle at time $t = 1$. Show the work that leads to your answer.

(a) $x'(t) = 15t^2 - 18t$

$x'(1) = 15 - 18 = -3$

Since $x'(1) < 0$, the particle is moving to the left at time $t = 1$.

$2 : \begin{cases} 1 : \text{considers } x'(1) \\ 1 : \text{answer with reason} \end{cases}$

(b) $x'(t) = 3t(5t - 6) = 0 \Rightarrow t = 0,\ t = \frac{6}{5}$

Since $x'(t) < 0$ for $0 < t < \frac{6}{5}$ and $x'(t) > 0$ for $t > \frac{6}{5}$, the particle is farthest to the left at time $t = \frac{6}{5}$.

$3 : \begin{cases} 1 : \text{considers } x'(t) = 0 \\ 1 : \text{identifies } t = \frac{6}{5} \\ 1 : \text{answer with reason} \end{cases}$

(c) Area $= A(t) = \frac{1}{2}x(t)y(t)$

$= \frac{1}{2}\left(5t^3 - 9t^2 + 7\right)(7t + 3)$

$A'(t) = \frac{1}{2}\left[\left(15t^2 - 18t\right)(7t + 3) + \left(5t^3 - 9t^2 + 7\right)(7)\right]$

$A'(1) = \frac{1}{2}[(-3)(10) + (3)(7)] = \frac{1}{2}[-30 + 21] = -\frac{9}{2}$

$4 : \begin{cases} 1 : \text{area function} \\ 2 : \text{derivative} \\ 1 : \text{answer} \end{cases}$

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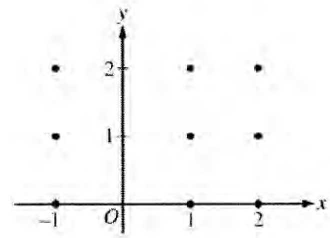
Question 6

Consider the differential equation $\frac{dy}{dx} = \left(1 - \frac{2}{x^2}\right)(y - 1)$, where $x \neq 0$.

Let $y = f(x)$ be the particular solution to the differential equation with initial condition $f(1) = 2$.



(a) Find the slope of the line tangent to the graph of f at the point $(1, 2)$.

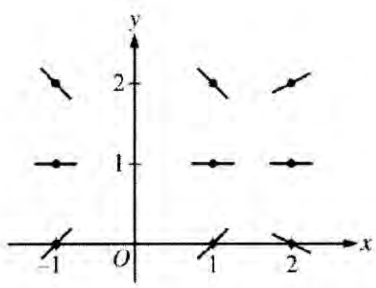
(b) On the axes provided, sketch a slope field for the given differential equation at the nine points indicated.

(c) Find the particular solution $y = f(x)$ to the differential equation $\frac{dy}{dx} = \left(1 - \frac{2}{x^2}\right)(y - 1)$ with initial condition $f(1) = 2$.

(a) $\left.\frac{dy}{dx}\right|_{(x,\,y)=(1,\,2)} = \left(1 - \frac{2}{1}\right)(2 - 1) = -1$

1 : answer

(b)



$2 : \begin{cases} 1 : \text{zero slope at each point } (x, y) \text{ where } y = 1 \\ 1 : \text{remaining slopes} \end{cases}$

(c) $\frac{dy}{dx} = \left(1 - \frac{2}{x^2}\right)(y - 1)$

$\int \frac{dy}{y-1} = \int \left(1 - \frac{2}{x^2}\right) dx$

$\ln|y - 1| = x + \frac{2}{x} + C$

$\ln|2 - 1| = 1 + \frac{2}{1} + C \Rightarrow C = -3$

$\ln|y - 1| = x + \frac{2}{x} - 3$

Note that $y - 1 > 0$ since the solution curve includes the point $(1, 2)$.

$\ln(y - 1) = x + \frac{2}{x} - 3$

$y = f(x) = e^{\left(x + \frac{2}{x} - 3\right)} + 1$

Note: This solution is valid for $x > 0$.

$6 : \begin{cases} 1 : \text{separation of variables} \\ 2 : \text{antiderivatives} \\ 1 : \text{constant of integration} \\ 1 : \text{uses initial condition} \\ 1 : \text{solves for } y \end{cases}$

Note: max $3/6$ [1-2-0-0-0] if no constant of integration

Note: $0/6$ if no separation of variables

2014 AP Calculus AB Scoring Worksheet

Section I: Multiple Choice

_______ × 1.2000 = _______

Number Correct (out of 45) | Weighted Section I Score (Do not round)

Section II: Free Response

Question 1 _______ (out of 9) × 1.0000 = _______ (Do not round)

Question 2 _______ (out of 9) × 1.0000 = _______ (Do not round)

Question 3 _______ (out of 9) × 1.0000 = _______ (Do not round)

Question 4 _______ (out of 9) × 1.0000 = _______ (Do not round)

Question 5 _______ (out of 9) × 1.0000 = _______ (Do not round)

Question 6 _______ (out of 9) × 1.0000 = _______ (Do not round)

Sum = _______
Weighted Section II Score (Do not round)

Composite Score

_______ + _______ = _______

Weighted Section I Score | Weighted Section II Score | Composite Score (Round to nearest whole number)

AP Score Conversion Chart
Calculus AB

Composite Score Range	AP Score
68-108	5
54-67	4
40-53	3
30-39	2
0-29	1