

2023 AP Calculus BC

Section I, Part A (1 hour No calculator 30 questions)

C

1. If $g(x) = x^2\sqrt{x+1}$, then $g'(3) =$

A. $3/2$

B. $39/4$

C. $57/4$

D. 36

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

C

2. $\int_0^4 100e^{\frac{x}{4}} dx =$

A. $25(e - 1)$

B. $100(e - 1)$

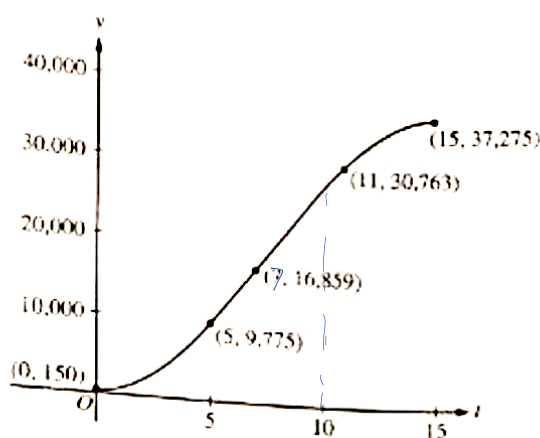
C. $400(e - 1)$

D. $400(e^4 - 1)$

$$\left[100 \cdot 4 \cdot e^{\frac{x}{4}} \right]_0^4$$

D

3.



An airplane's height above sea level is modeled by the differentiable function $y = h(t)$, where t is the number of minutes after takeoff and $h(t)$ is measured in feet. The graph of h is shown in the figure for $0 \leq t \leq 15$. Of the following, which is the best estimate of the rate at which the plane is rising above sea level, in feet per minute, at time $t = 9$?

- A. $\frac{37,275-150}{15-0}$
 B. $\frac{37,275-9,775}{15-5}$
 C. $\frac{37,275-16,859}{15-7}$
 D. $\frac{30,763-16,859}{11-7}$

A

4. Let f be a vector-valued function with $f(0) = \langle -2, 3 \rangle$. If the instantaneous rate of f with respect to t is given by $\langle 3t^2 + 4t + 1, 2t^3 + t - 2 \rangle$, what is $f(1)$?

- A. $\langle 2, 2 \rangle$
 B. $\langle 4, -1 \rangle$
 C. $\langle 8, 10 \rangle$
 D. $\langle 10, 7 \rangle$

$$x = -2 + \int_0^1 (3t^2 + 4t + 1) dt = 2$$

$$y = 3 + \int_0^1 (2t^3 + t - 2) dt = 2$$

A

5. $\lim_{x \rightarrow 4} \frac{2 - \sqrt{x}}{x - 4} = \lim_{x \rightarrow 4} \frac{-\frac{1}{2\sqrt{x}}}{1} = -\frac{1}{4}$

- A. $-\frac{1}{4}$
 B. 0
 C. $\frac{1}{4}$
 D. Nonexistent

D

6. Let $y = f(x)$ be the solution to the differential equation $\frac{dy}{dx} = x + y^2$ with initial condition $f(1) = 2$. What is the approximation for $f(1.4)$, if Euler's method is used, starting at $x = 1$ with two steps of equal size?

- A. 2.4
 B. 3.04
 C. 4
 D. 5.04

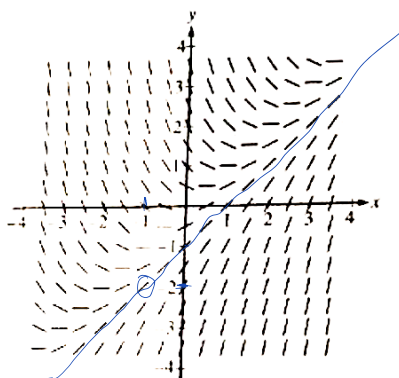
$$f(1.2) \approx f(1) + f'(1)(1.2 - 1) \\ = 2 + (1 + 2^2) \cdot (0.2) = 3$$

$$f(1.4) \approx f(1.2) + f'(1.2)(1.4 - 1.2)$$

$$= 3 + \left(1.2 + 3^2\right) \cdot (0.2)$$

$$= 5.04$$

7.



A portion of the slope field for the differential equation $\frac{dy}{dx} = x - y$ is shown in the figure. If the linear function $y = f(x)$ is the solution to the differential equation such that $f(-1) = -2$, then $f(3) =$

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

$\text{slope} = 1$
 $y + 2 = x + 1$
 $y = x - 1$

8. If $f(x) = \sin(e^{3x})$, then $f'(x) =$

- A. $\cos(e^{3x})$
B. $\cos(3e^{3x})$
C. $e^{3x} \cos(e^{3x})$
D. $3e^{3x} \cos(e^{3x})$

9. If the series converges, where $A \neq 0$ and $B \neq 0$, what is the sum of the series?

$$\sum_{n=0}^{\infty} (-1)^n \frac{B^{n+1}}{A^n}$$

$a = \frac{B^1}{A^0} = B$
 $r = (-1) \cdot \frac{B}{A} = -\frac{B}{A}$

- A. $\frac{AB}{A-B}$
B. $\frac{AB}{A+B}$
C. $\frac{A}{A-B}$

$\frac{a}{1-r} = \frac{B}{1 + \frac{B}{A}} = B \frac{A}{A+B}$

D. $\frac{A}{A+B}$

10. Of the following series, which can be used with the comparison test to show that diverges?

$$\sum_{n=3}^{\infty} \frac{\ln n}{n}$$

A. $\sum_{n=3}^{\infty} \frac{1}{n}$ diverge $\lim_{n \rightarrow \infty} \left| \frac{\ln n}{n} \cdot n \right| = \lim_{n \rightarrow \infty} |\ln n| = \infty$

B. $\sum_{n=3}^{\infty} \frac{1}{n\sqrt{n}}$ converge (p-series)

C. $\sum_{n=3}^{\infty} \frac{1}{n^2}$ converge

D. $\sum_{n=3}^{\infty} \ln n$ diverge $\lim_{n \rightarrow \infty} \left| \frac{\ln n}{\ln n} \right| = \lim_{n \rightarrow \infty} \left| \frac{1}{n} \right| = 0$ $\ln n$ converge $\frac{\ln n}{n}$ converge X

11. A particle moves in the xy-plane so that its position at any time t is given by the parametric equations $x(t) = t^2 - t^3$ and $y(t) = 9 - 6t$. What is the speed of the particle at time $t = 2$?

A. $\frac{3}{4}$

B. 5

C. 10

D. 14

$$\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}$$

$$= \sqrt{(4-12)^2 + (-6)^2} = 10$$

12. Which of the following is the solution to the differential equation $\frac{dy}{dx} = -3y$ with the initial condition $y(0) = 2$?

A. $y = 7e^{-3x}$

B. $y = e^{-3x} + 6$

C. $y = -\frac{3}{2}x^2 + 7$

D. $y = \sqrt{49 - 6x}$

$$\int \frac{1}{y} dy = \int -3 dx$$

$$\ln|y| = -3x + C$$

$$y = k \cdot e^{-3x}$$

$$k = 7$$

$$y = 7e^{-3x}$$

C

13. Consider the series. Which of the following statements is true?

$$\sum_{n=1}^{\infty} \frac{(-1)^n}{\cos\left(\frac{1}{n}\right)} \quad \lim_{n \rightarrow \infty} \cos\left(\frac{1}{n}\right) \neq 0$$

- A. The series converges absolutely.
- B. The series converges conditionally.
- C. The series diverges.
- D. It cannot be determined whether the series converges or diverges from the information given.

D

14. If f is a function such that $\lim_{x \rightarrow \infty} f(x) = 0$, which of the following could be an expression for $f(x)$?

A. $\frac{x^2}{x^2+4}$

B. $\frac{\sin x}{x}$

C. $\cos x$

D. e^x

$$\lim_{x \rightarrow -\infty} e^x = 0$$

A

15. $\int \frac{x+1}{x(x+3)} dx =$

A. $\frac{1}{3} \ln|x| + \frac{2}{3} \ln|x+3| + C$

B. $\frac{1}{3} \ln|x| + \frac{2}{9} \ln|x+3| + C$

C. $\frac{2}{3} \ln|x| + \frac{1}{3} \ln|x+3| + C$

D. $\frac{2}{3} \ln|x| + \frac{1}{9} \ln|x+3| + C$

$$\frac{A}{x} + \frac{B}{x+3}$$

$$A(x+3) + Bx = x+1$$

$$(A+B)x + 3A = x+1$$

$$\begin{cases} A+B=1 \\ 3A=1 \end{cases} \Rightarrow \begin{matrix} A=\frac{1}{3} \\ B=\frac{2}{3} \end{matrix}$$

16. $f(x) = \begin{cases} x^2 - 2x, & x \leq 4 \\ g(x), & x > 4 \end{cases}$

A

Let f be the function defined as shown. If f is differentiable, which of the following could define $g(x)$?

A. $6x$

B. $x^{3/2}$

C. $x^2 - 8$

D. $\frac{1}{8}x^3$

$$\lim_{x \rightarrow 4} f'(x) = 2 \cdot (4) - 2 = 6$$

17. The function $y = f(x)$ satisfies the differential equation $\frac{dy}{dx} = 2xy$ with the initial condition $f(0) = 5$. What is the value of $f(2)$?

D

A. $\frac{5}{21}$

B. $\sqrt{33}$

C. $4 + e^4$

D. $5e^4$

$$\int \frac{1}{y} dy = \int 2x dx \quad K=5$$

$$\ln|y| = x^2 + C \quad y = 5e^{x^2}$$

$$y = ke^{x^2} \quad f(2) = 5 \cdot e^4$$

18. Which of the following gives the length of the curve $y = \tan x$ from $x = -\frac{\pi}{4}$ to

D

$x = \frac{\pi}{4}$?

A. $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \sqrt{1 - \tan x} dx$

B. $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \sqrt{1 + \tan^2 x} dx$

C. $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \sqrt{1 + \sec^2 x} dx$

D. $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \sqrt{1 + \sec^4 x} dx$

$$(\tan x)' = \sec^2 x$$

$$\int_a^b \sqrt{1 + \left(\frac{dy}{dx}\right)^2} dx$$

19. If $y = f(x)$ is a function such that $\frac{dy}{dx} = \frac{2x-y}{x}$, then $\frac{d^2y}{dx^2} =$

A

A. $\frac{2y-2x}{x^2}$

B. $\frac{y-xy}{x^2}$

C. $\frac{y-x}{x^2}$

D. $\frac{y}{x^2}$

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

$$\frac{(2 - \frac{2x-y}{x})x - 2x + y}{x^2} = \frac{2x - 2x + y - 2x + y}{x^2}$$

20. Which of the following series converges to $\frac{1}{e}$?

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

B

A. $\sum_{n=0}^{\infty} \frac{1}{n!}$

B. $\sum_{n=0}^{\infty} \frac{(-1)^n}{n!}$

C. $\sum_{n=0}^{\infty} \frac{(-1)^n}{(2n)!}$

D. $\sum_{n=0}^{\infty} \frac{(-1)^{n+1}}{(2n+1)!}$

$$e^x = 1 + x + \frac{x^2}{2!} + \dots + \frac{x^n}{n!}$$

$$e^{-1} = 1 + (-1) + \frac{(-1)^2}{2!} + \frac{(-1)^3}{3!} + \dots + \frac{(-1)^n}{n!}$$

B

21. The function g has a continuous second derivative. If $g(0) = 2$, $g'(0) = 4$, $g(3) = 5$ and $g'(3) = 6$, what is the value of $\int_0^3 x \cdot g''(x) dx$?

A. 9

B. 15

C. 21

D. 27

$$\begin{aligned} \int_0^3 x \cdot g''(x) dx &= [xg'(x) - g(x)]_0^3 \\ &= (3g'(3) - g(3)) - (0 - g(0)) \\ &= (3 \cdot 6 - 5) + 2 \\ &= 15 \end{aligned}$$

22. The Maclaurin series for the function f is given below. What is the value of $f^{(4)}(0)$?

D

A. 2

B. 4

C. 8

D. 48

$$\sum_{n=1}^{\infty} \frac{(-2)^n x^{2n}}{n}$$

$$\frac{f^{(4)}(0) x^4}{4!} = \frac{(-2)^2 x^{2n}}{2} = 2 \cdot x^4$$

$$f^{(4)}(0) = 4! \cdot 2 = 48$$

23. Let f be a differentiable function such that $f(\pi) = 2$ and $f'(\pi) = -3$. What is the slope of the line tangent to the polar curve $r = f(\theta)$ at $\theta = \pi$?

D

A. -3

B. -2

C. $-\frac{3}{2}$ D. $-\frac{2}{3}$

$$\begin{aligned} x &= r \cos \theta = f(\theta) \cos \theta \\ \frac{dx}{d\theta} &= f'(\theta) \cos \theta + f(\theta) (-\sin \theta) \\ y &= r \sin \theta = f(\theta) \sin \theta \\ \frac{dy}{d\theta} &= f'(\theta) \sin \theta + f(\theta) \cos \theta \end{aligned}$$

$$\begin{aligned} \cos(\pi) &= -1 \\ \sin(\pi) &= 0 \\ \frac{dy}{dx} &= \frac{-3 \cdot 0 + 2(-1)}{-3(-1) + 0} \\ &= \frac{-2}{3} \end{aligned}$$

24. $\int_{-\infty}^1 x^2 2^{x^3} dx$ is

B

A. $\frac{6}{\ln 2}$ B. $\frac{2}{3 \ln 2}$ C. $\frac{2 \ln 2}{3}$

D. divergent

$$\begin{aligned} u &= x^3 \\ \frac{du}{dx} &= 3x^2 \quad dx = \frac{du}{3x^2} \\ \int_{-\infty}^1 x^2 2^{x^3} \cdot \frac{du}{3x^2} &= \frac{1}{3} \int_{-\infty}^1 2^u du = \frac{1}{3} \cdot \frac{2^u}{\ln 2} + C \\ \left[\frac{1}{3 \ln 2} \cdot 2^u \right]_{-\infty}^1 &= \frac{1}{3 \ln 2} \cdot 2 - \frac{1}{3 \ln 2} \cdot 2^{-\infty} = \frac{2}{3 \ln 2} \end{aligned}$$

A

$$25. \int \frac{dx}{x^2+4x+5} = \int \frac{1}{(x+2)^2+1} dx$$

A. $\tan^{-1}(x+2) + C$

B. $\ln|x^2+4x+5| + C$

C. $\frac{1}{2x+4} \ln|x^2+4x+5| + C$

D. $\frac{1}{\frac{1}{3}x^3+2x^2+5x} + C$

26. Let f be a function defined by $f(x) = x^3 + x$. If g is the reverse function of f ,

D

what is the slope of the line tangent to the graph of g at the point $(2,1)$?

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

B. $-\frac{1}{13}$

C. $\frac{1}{13}$

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

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

$$\begin{cases} f(a) = 2 \\ g(2) = a \end{cases} \Rightarrow a = 1$$

$$f'(x) = 3x^2 + 1$$

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

x	0	2	3	5
$f(x)$	2	3	6	12

A

27. The function f is continuous on the closed interval $[0,5]$ and differentiable on the open interval $(0,5)$. Selected values of f are given in the table shown. The value $c = 4$ satisfies the conclusion of the Mean Value Theorem for f on the closed interval $[0,5]$. What is the slope of the line tangent to graph of f at $x = 4$?

A. 2

B. 2.8

C. 4.5

D. 10

$$f'(4) = \frac{f(5) - f(0)}{5 - 0} = \frac{12 - 2}{5} = 2$$

28. Let f be a function with $f(0) = 0$ and derivative given by $f'(x) = \cos(x^2)$.

Which of the following is the Maclaurin series for f ?

A. $\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n}}{(2n)!}$

B. $\sum_{n=0}^{\infty} \frac{(-1)^n x^{4n}}{(2n)!}$

C. $\sum_{n=0}^{\infty} \frac{(-1)^n x^{4n+1}}{(4n+1)(2n)!}$

D. $\sum_{n=0}^{\infty} \frac{(-1)^n (4n) x^{4n-1}}{(2n)!}$

$\cos x = 1 - \frac{1}{2!} x^2 + \frac{1}{4!} x^4 - \dots$

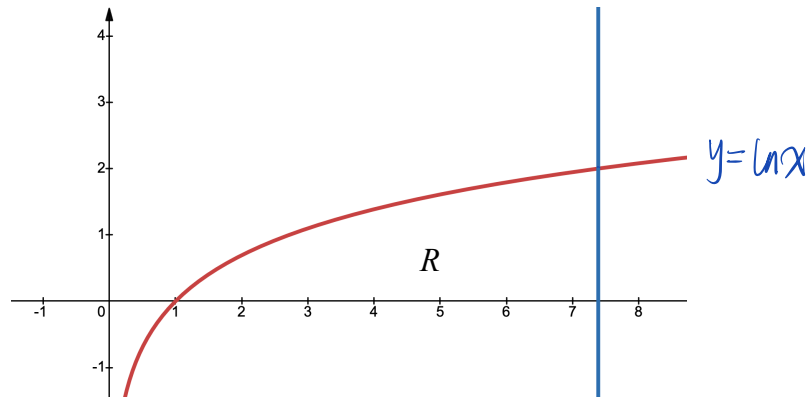
$f'(x) = \cos(x^2) = 1 - \frac{1}{2!} x^4 + \frac{1}{4!} x^8 - \dots$

$f(x) =$

$(-1)^n \cdot \frac{1}{(2n)!} x^{2n}$

$(-1)^n \cdot \frac{1}{(2n)!} \cdot x^{4n}$

$(-1)^n \cdot \frac{1}{(2n)!} \cdot \frac{x^{4n+1}}{4n+1}$



29. Let R be the region bounded by the graph of $y = \ln x$, the vertical line $x = e^2$, and the x -axis, as shown in the figure. Which of the following integrals are equal to the area of R ?

I. $\int_1^{e^2} \ln x \, dx$

II. $\int_0^2 e^y \, dy$

III. $\int_0^2 (e^2 - e^y) \, dy$

A. I only

B. III only

C. I and II only

D. I and III only

C 30. $\lim_{n \rightarrow \infty} \sum_{k=1}^n \left(\frac{3}{n}k\right)^2 \left(\frac{3}{n}\right)$ is $\left(\frac{3}{n}\right)^2 \cdot \frac{3}{n} + \left(\frac{3}{n} \cdot 2\right)^2 \cdot \frac{3}{n} + \left(\frac{3}{n} \cdot 3\right)^2 \cdot \frac{3}{n}$

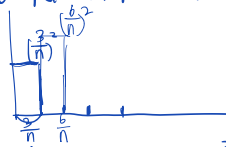
A. 1

B. 3

C. 9

D. nonexistent

Right Riemann Sum



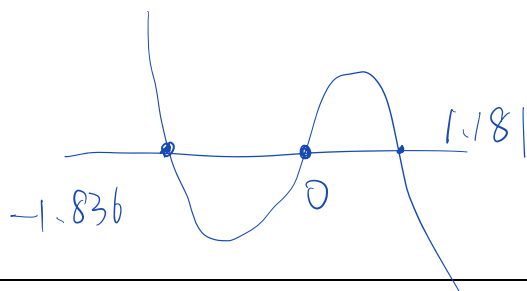
$$\int_0^3 x^2 dx = \left[\frac{1}{3}x^3\right]_0^3 = 9 - 0 = 9$$

Section I, Part B (45 minutes calculator 15 questions)

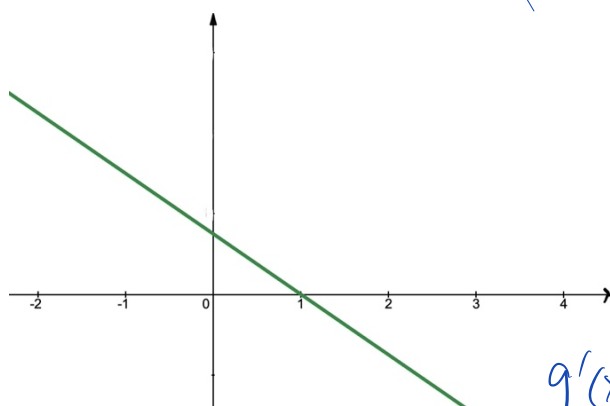
C

76. If $f'(x) = 1 + 2x - x^3 - \sqrt{x^4 + 1}$, then f has a local minimum at $x =$

- A. -1.836
- B. -1.117
- C. 0
- D. 1.181



$f'(x)$ 从负变正

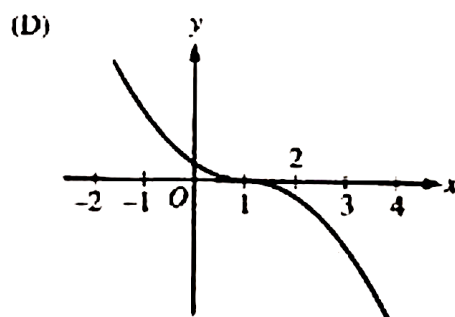
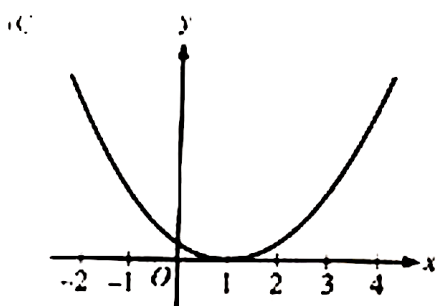
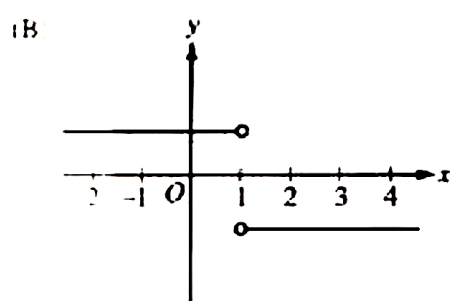
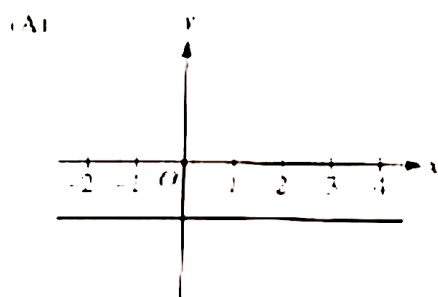


Graph of g

$g'(x) = f(x)$ slope 恒定不变 < 0

77. The preceding figure shows the graph of g . If $g(x) = \int_1^x f(t)dt$, which of the following could be the graph of $y = f(x)$?

A



x	-1	1
$f(x)$	10	0
$f'(x)$	-1	-9
$f''(x)$	23	-13
$f'''(x)$	-42	6

C

78. The function f has derivatives of all orders for all real numbers. The table shown gives values of f and its first three derivatives at selected values of x . What is the value of $\int_{-1}^1 f''(x) dx$?

A. -36

B. -10

C. -8

D. 48

$$= [f'(x)]_{-1}^1 = f'(1) - f'(-1) = -9 - (-1) = -8$$

B

79. On a certain day, an industrial plant manufactures steel at a rate modeled by $R(t) = 10 + 30e^{-0.6t}$ tons per hour, where t is measured in hours since the plant opened that day. What is the average rate at which the plant manufactures steel, in tons per hour, over the time interval $0 \leq t \leq 5$?

A. 11.494

B. 19.502

C. 25.747

D. 97.511

$$\frac{\int_0^5 10 + 30e^{-0.6t} dt}{5-0}$$

C

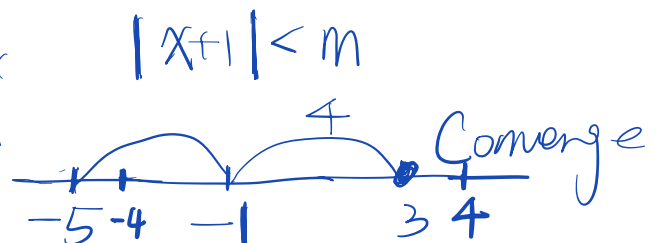
80. The power series $\sum_{n=0}^{\infty} a_n(x+1)^n$ converges at $x = 3$. Which of the following must be true?

A. $\sum_{n=0}^{\infty} a_n(x+1)^n$ converges at $x = -5$ X

B. $\sum_{n=0}^{\infty} a_n(x+1)^n$ diverges at $x = -5$ X

C. $\sum_{n=0}^{\infty} a_n(x+1)^n$ converges at $x = -4$

D. $\sum_{n=0}^{\infty} a_n(x+1)^n$ diverges at $x = 4$



3是右边端点的话对应左边-5, -5无法判断 converge or diverge 但-4一定converge
4这个¹²⁴因为在最右边, 无法判断

81. A thin rectangular sheet of metal expands in a hot oven. At the instant when the width of the rectangular sheet of metal is 200 millimeters and the length is 300 millimeters, the width is increasing at a rate of 2 millimeters per minute, and the length is increasing at a rate of 3 millimeters per minute. What is the rate of change of the area, in square millimeters per minute, of the rectangular sheet of metal at that instant?

- A. 5
B. 6
C. 600
D. 1200
- $W = 200$
 $L = 300$
 $\frac{dW}{dt} = 2$
 $\frac{dL}{dt} = 3$
 $A = WL$
 $\frac{dA}{dt} = \frac{dW}{dt} \cdot L + W \frac{dL}{dt}$
 $= 2 \cdot 300 + 200 \cdot 3 = 1200$

82. A particle travels along x -axis so that its velocity at time $t \geq 0$ is given by

$\frac{dy}{dx} = \sin(t^2)$. What is the total distance the particle travels from $t = 0$ to $t = 2.7$?

- A. 0.519
B. 0.845
C. 1.448
D. 2.887

$$\int_0^{2.7} |\sin(t^2)| dt$$

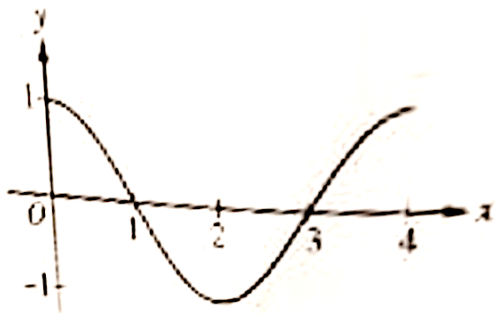
83. The function f is continuous on the closed interval $[a, b]$, where a and b are constants and $a < b$. If $f(a) < 0 < f(b)$, which of the following statements must be true?

- A. There is at least one value of x in the interval (a, b) such that $f(x) = 0$ IVT
 B. There is at least one value of x in the interval (a, b) such that $f'(x) = \frac{f(b) - f(a)}{b - a}$ MVT
 C. $f'(x) > 0$ for all x in the interval (a, b) not differentiable
 D. $f(a) < f(x) < f(b)$ for all x in the interval (a, b)

84. The alternating series $\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{2n+2}$ converges to S . If the sum of the first six terms of the series is used to approximate S . What is the alternating series error bound?

- A. $1/6$
B. $1/7$
C. $1/14$
D. $1/16$
- error bound (seventh term) = $\frac{1}{2 \cdot 7 + 2} = \frac{1}{16}$

C



85. The graph of a twice-differentiable function f is shown for $0 < x < 4$. The graph of f has a horizontal tangent at $x = 2$ and points of inflection at $x = 1$ and $x = 3$. On what intervals do $f'(x)$ and $f''(x)$ have the same sign?

A. $0 < x < 1$ only

B. $2 < x < 4$

C. $0 < x < 1$ and $2 < x < 3$

$$f'(x) < 0 \quad f''(x) < 0$$

D. $1 < x < 2$ and $3 < x < 4$

x	$f(x)$	$f'(x)$	$g(x)$	$g'(x)$
2	-6	7	4	-1
4	5	6	0	5

86. The table shown gives values of the twice-differentiable function f and g and their derivatives f' and g' at selected values of x . What is $\lim_{x \rightarrow 2} \frac{g(x^2)}{3x + f(x)}$?

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

B. $\frac{20}{13}$

C. 2

D. The limit does not exist.

$$\lim_{x \rightarrow 2} \frac{g'(x^2) \cdot 2x}{3 + f'(x)} = \frac{5 \cdot 2 \cdot 2}{3 + 7} = 2$$

B

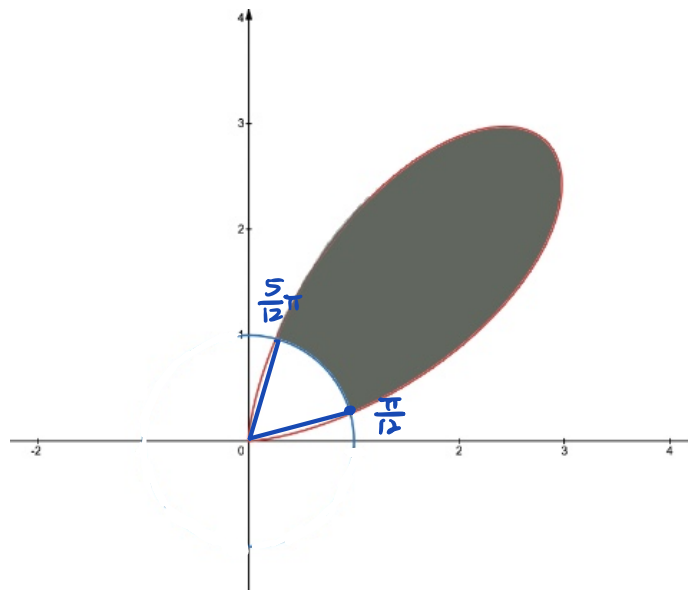
87. The velocity of a particle moving along the x -axis is given by $v(t) = \frac{1-t^3}{1+t}$ for time $t \geq 0$. Which of the following statements is true about the particle at time $t = 1.5$?

- A. The acceleration is negative, and the speed is decreasing
- B. The acceleration is negative, and the speed is increasing
- C. The acceleration is positive, and the speed is decreasing
- D. The acceleration is positive, and the speed is increasing

$$V(1.5) = -0.95 < 0$$

$$a(1.5) < 0$$

speed increasing



B

88. The figure shows the graphs of the polar curve $r = 4(\sin(2\theta))^2$ and $r = 1$ for $0 \leq \theta \leq \frac{\pi}{2}$. What is the area of the shaded region?

A. 8.267

B. 4.134

C. 3.927

D. 1.913

$$\frac{1}{2} \int_{\frac{\pi}{12}}^{\frac{5\pi}{12}} (4(\sin(2\theta))^2)^2 d\theta - \frac{1}{2} \cdot \left(\frac{4}{12}\pi\right) \cdot 1^2$$

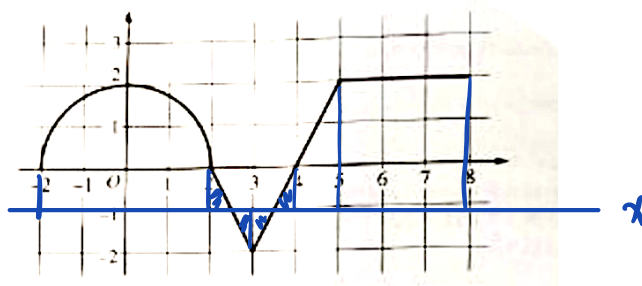
$$4(\sin(2\theta))^2 = 1$$

$$(\sin(2\theta))^2 = \frac{1}{4}$$

$$\sin(2\theta) = \frac{1}{2}$$

$$2\theta = \frac{\pi}{6} \text{ or } \frac{5}{6}\pi$$

$$\theta = \frac{\pi}{12} \text{ or } \frac{5}{12}\pi$$



Graph of f

- C 89. The graph of the function f shown consists of a semicircle centered at the origin and three line segments. If $g(x) = \int_{-2}^x (f(t) + 1) dt$, then $g(8) =$

- A. $2\pi + 6$
 B. $2\pi + 10$
 C. $2\pi + 15$
 D. $2\pi + 19$

$$\pi \cdot 2^2 \cdot \frac{1}{2} + 4 + 2 + 9 = 2\pi + 15$$

- B 90. The position of a particle moving in the xy -plane is given by the parametric equation $x(t) = 5 \ln(t + 5)$ and $y(t) = 5 \sin(\pi t)$. At any point on the curve, the slope of the line tangent to the path of the particle is given by $\frac{dy}{dx} = \pi \cos(\pi t) (t + 5)$.

What is the value of $\frac{d^2y}{dx^2}$ at $t = 1$? $\sin(\pi) = 0$
 $\cos(\pi) = -1$

- A. -18.850
 B. -3.770
 C. -3.142
 D. 0.200

$$\begin{aligned} \frac{d^2y}{dx^2} &= \frac{\left(\frac{dy}{dx}\right)'}{\frac{dx}{dt}} = \frac{\pi \cdot (-\sin(\pi t)) \cdot \pi \cdot (t+5) + \pi \cos(\pi t) \cdot 1}{5 \cdot \frac{1}{t+5}} \\ &= \frac{-\pi}{\frac{5}{6}} = -\pi \cdot \frac{6}{5} \end{aligned}$$