AP® Precalculus

Practice Exam: Section I
Multiple-Choice Questions

PRECALCULUS

SECTION I, Part A

Time—1 hour, 20 minutes

Number of questions—28

NO CALCULATOR IS ALLOWED FOR THIS PART OF THE EXAM.

Directions: Solve each of the following problems, using the available space for scratch work. After examining the choices, decide which is the best of the choices given and fill in the corresponding circle on the answer sheet. No credit will be given for anything written in this exam booklet. Do not spend too much time on any one problem.

In this exam:

(1) Unless otherwise specified, the domain of a function f is assumed to be the set of all real numbers x for which $f(x)$ is a real number.

(2) Angle measures for trigonometric functions are assumed to be in radians.

1. A polynomial function p is given by $p(x) = -x(x-4)(x+2)$. What are all intervals on which $p(x) \geq 0$?

(A) $[-2, 4]$

(B) $[-2, 0] \cup [4, \infty)$

(C) $(-\infty, -4] \cup [0, 2]$

(D) $(-\infty, -2] \cup [0, 4]$

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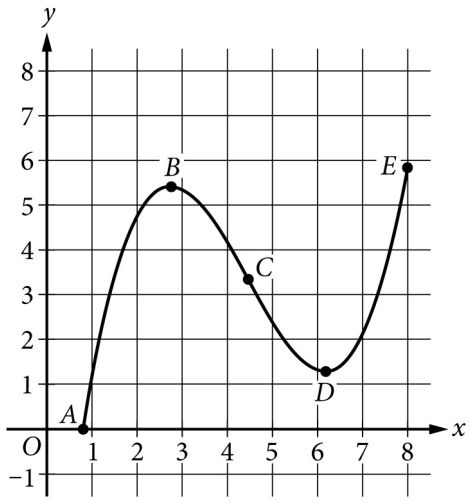
2. The function f is given by $f(x) = 9 \cdot 25^x$. Which of the following is an equivalent form for $f(x)$?

(A) $f(x) = 3 \cdot 5^{(x/2)}$

(B) $f(x) = 3 \cdot 5^{(2x)}$

(C) $f(x) = 9 \cdot 5^{(x/2)}$

(D) $f(x) = 9 \cdot 5^{(2x)}$



Graph of f

3. The figure shows the graph of a function f. The zero and extrema for f are labeled, and the point of inflection of the graph of f is labeled. Let A, B, C, D, and E represent the x-coordinates at those points. Of the following, on which interval is f increasing and the graph of f concave down?

(A) the interval from A to B

(B) the interval from B to C

(C) the interval from C to D

(D) the interval from D to E

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4. The function f is given by $f(x) = 5x^6 - 2x^3 - 3$. Which of the following describes the end behavior of f ?

(A) $\lim_{x \to -\infty} f(x) = -\infty$ and $\lim_{x \to \infty} f(x) = -\infty$

(B) $\lim_{x \to -\infty} f(x) = \infty$ and $\lim_{x \to \infty} f(x) = \infty$

(C) $\lim_{x \to -\infty} f(x) = -\infty$ and $\lim_{x \to \infty} f(x) = \infty$

(D) $\lim_{x \to -\infty} f(x) = \infty$ and $\lim_{x \to \infty} f(x) = -\infty$

5. Let x and y be positive constants. Which of the following is equivalent to $2\ln x - 3\ln y$?

(A) $\ln\left(\frac{x^2}{y^3}\right)$

(B) $\ln\left(x^2 y^3\right)$

(C) $\ln(2x-3y)$

(D) $\ln\left(\frac{2x}{3y}\right)$

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6. The polynomial function p is given by $p(x)=(x+3)\left(x^2-2x-15\right)$. Which of the following describes the zeros of p ?

(A) p has exactly two distinct real zeros.

(B) p has exactly three distinct real zeros.

(C) p has exactly one distinct real zero and no non-real zeros.

(D) p has exactly one distinct real zero and two non-real zeros.

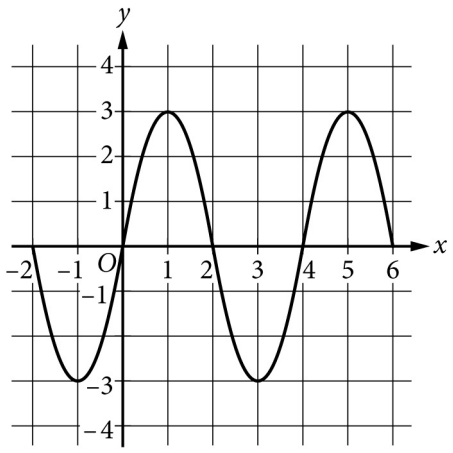
7. In the xy-plane, the graph of a rational function f has a vertical asymptote at $x = -5$. Which of the following could be an expression for $f(x)$?

(A) $\dfrac{(x-5)(x+5)}{2(x-5)}$

(B) $\dfrac{(x-4)(x+5)}{(x-1)(x+5)}$

(C) $\dfrac{(x+1)(x+5)}{(x-5)(x+2)}$

(D) $\dfrac{(x-5)(x-3)}{(x-3)(x+5)}$



Graph of f

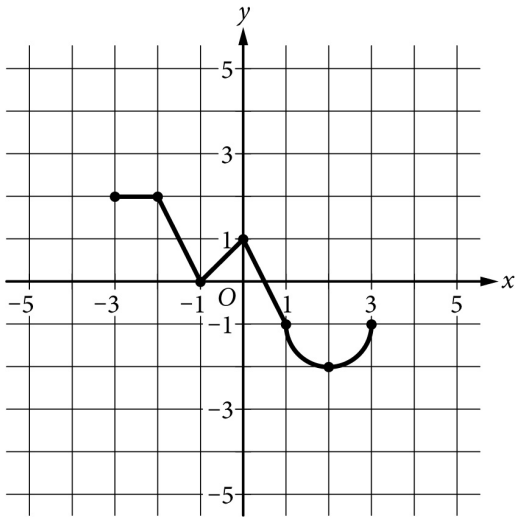
8. Let f be a sinusoidal function. The graph of $y = f(x)$ is given in the xy-plane. What is the period of f ?

(A) 2

(B) 3

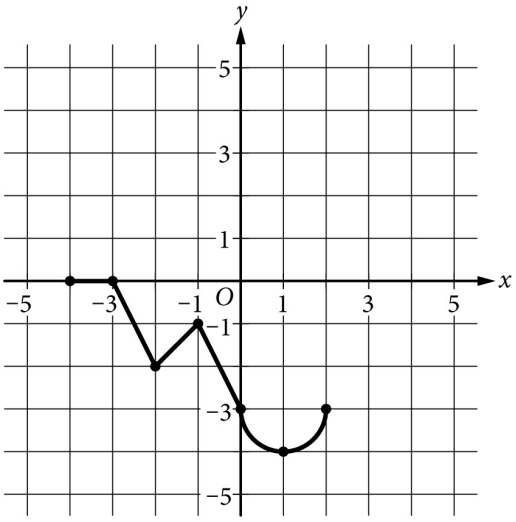
(C) 4

(D) 6



9. The graph of $y = f(x)$, consisting of four line segments and a semicircle, is shown for $-3 \le x \le 3$. Which of the following is the transformed graph for $y = f(x+1) - 2$?

(A)



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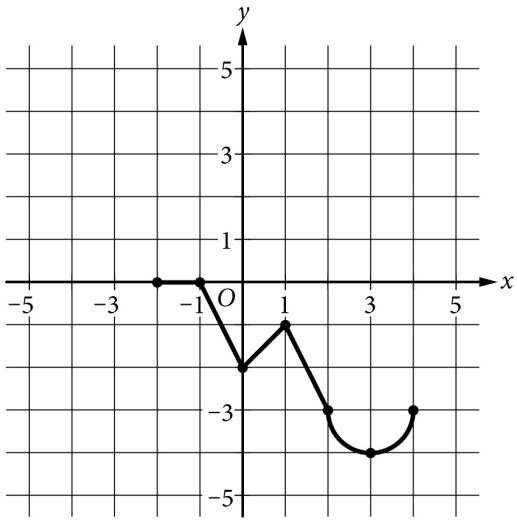

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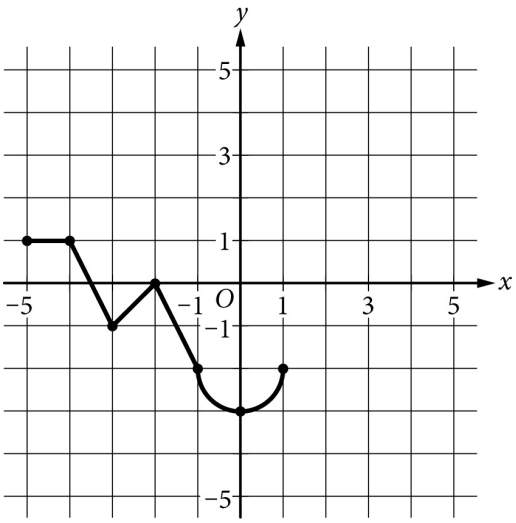

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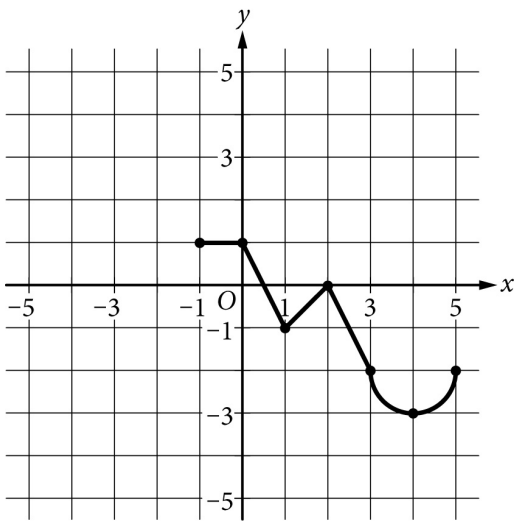

x	0	1	2	3	4
$f(x)$	$\frac{3}{4}$	$\frac{3}{2}$	3	6	12

10. The exponential function f is defined by $f(x) = ab^x$, where a and b are positive constants. The table gives values of $f(x)$ at selected values of x. Which of the following statements is true?

(A) f demonstrates exponential decay because $a > 0$ and $0 < b < 1$.

(B) f demonstrates exponential decay because $a > 0$ and $b > 1$.

(C) f demonstrates exponential growth because $a > 0$ and $0 < b < 1$.

(D) f demonstrates exponential growth because $a > 0$ and $b > 1$.

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11. The function f is given by $f(x) = x^2 + 1$, and the function g is given by $g(x) = \frac{(x-3)}{x}$. Which of the following is an expression for $f(g(x))$?

(A) $\frac{x^3 - 3x^2 + x - 3}{x}$

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

(C) $\frac{x^2 - 6x + 9}{x^2} + 1$

(D) $\frac{x^2 - 8}{x^2}$

x	$g(x)$
0	53
1	78
2	97
3	110
4	117

12. The table shows values for a function g at selected values of x. Which of the following claim and explanation statements best fits these data?

(A) g is best modeled by a linear function, because the rate of change over consecutive equal-length input-value intervals is constant.

(B) g is best modeled by a linear function, because the change in the average rates of change over consecutive equal-length input-value intervals is constant.

(C) g is best modeled by a quadratic function, because the rate of change over consecutive equal-length input-value intervals is constant.

(D) g is best modeled by a quadratic function, because the change in the average rates of change over consecutive equal-length input-value intervals is constant.

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13. The function g is given by $g(x) = 7\sin(2x)$. Which of the following is an equivalent form for $g(x)$?

(A) $g(x) = 14\cos x \sin x$

(B) $g(x) = (7\cos x)(7\sin x)$

(C) $g(x) = 7\cos^2 x - 7\sin^2 x$

(D) $g(x) = 7 - 14\sin^2 x$

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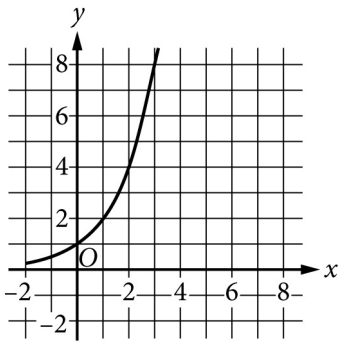
14. The function g has the property that for each time the input values double, the output values increase by 1. Which of the following could be the graph of $y = g(x)$ in the xy-plane?

(A)



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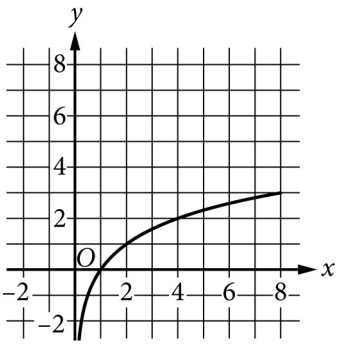

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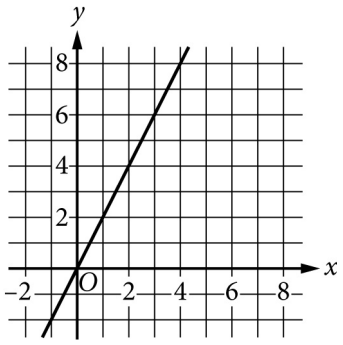
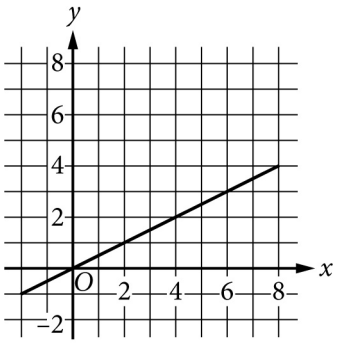


(D)



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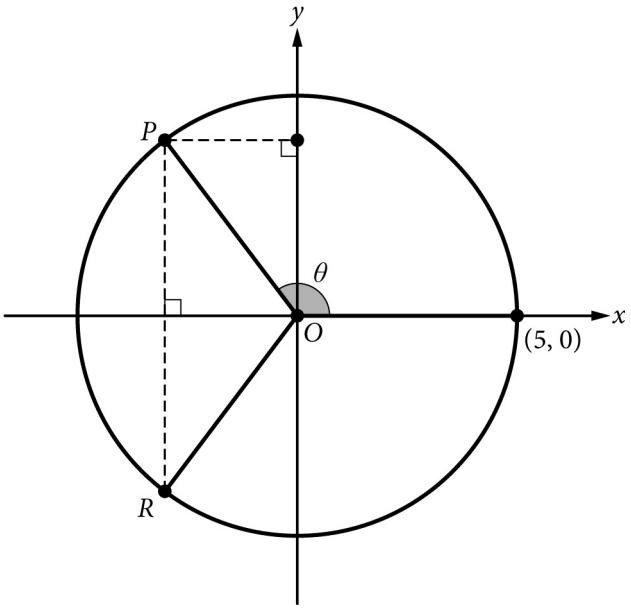
15. A complex number is represented by a point in the complex plane. The complex number has the rectangular coordinates $(3, 3)$. Which of the following is one way to express the complex number using its polar coordinates (r, θ) ?

(A) $\left(3\sqrt{2}\cos\left(\frac{\pi}{4}\right)\right) + i\left(3\sqrt{2}\sin\left(\frac{\pi}{4}\right)\right)$

(B) $\left(3\cos\left(\frac{\pi}{4}\right)\right) + i\left(3\sin\left(\frac{\pi}{4}\right)\right)$

(C) $\left(3\sqrt{2}\cos\left(-\frac{\pi}{4}\right)\right) + i\left(3\sqrt{2}\sin\left(-\frac{\pi}{4}\right)\right)$

(D) $\left(3\cos\left(-\frac{\pi}{4}\right)\right) + i\left(3\sin\left(-\frac{\pi}{4}\right)\right)$



16. The figure shows a circle centered at the origin with an angle of measure θ radians in standard position. The terminal ray of the angle intersects the circle at point P, and point R also lies on the circle. The coordinates of P are (x, y), and the coordinates of R are $(x, -y)$. Which of the following is true about the sine of θ ?

(A) $\sin\theta = \frac{x}{5}$, because it is the ratio of the horizontal displacement of P from the y-axis to the distance between the origin and P.

(B) $\sin\theta = \frac{x}{5}$, because it is the ratio of the horizontal displacement of R from the y-axis to the distance between the origin and R.

(C) $\sin\theta = \frac{-y}{5}$, because it is the ratio of the vertical displacement of R from the x-axis to the distance between the origin and R.

(D) $\sin\theta = \frac{y}{5}$, because it is the ratio of the vertical displacement of P from the x-axis to the distance between the origin and P.

17. The function f is given by $f(x) = 3x^2 + 2x + 1$. The graph of which of the following functions is the image of the graph of f after a vertical dilation of the graph of f by a factor of 2 ?

(A) $m(x) = 12x^2 + 4x + 1$, because this is a multiplicative transformation of f that results from multiplying each input value x by 2.

(B) $k(x) = 6x^2 + 4x + 2$, because this is a multiplicative transformation of f that results from multiplying $f(x)$ by 2.

(C) $p(x) = 3(x + 2)^2 + 2(x + 2) + 1$, because this is an additive transformation of f that results from adding 2 to each input value x.

(D) $n(x) = 3x^2 + 2x + 3$, because this is an additive transformation of f that results from adding 2 to $f(x)$.

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x	-2	-1	0	1	2
$f(x)$	1	2	-1	-2	0
$g(x)$	2	0	1	-1	0

18. The table gives values for the functions f and g at selected values of x. Functions f and g are defined for all real numbers. Let h be the function defined by $h(x) = f(g(x))$. What is the value of $h(0)$?

(A) -2

(B) -1

(C) 0

(D) 2

19. The functions f and g are defined for all real numbers such that $g(x) = f\big(2(x-4)\big)$. Which of the following sequences of transformations maps the graph of f to the graph of g in the same xy-plane?

(A) A horizontal dilation of the graph of f by a factor of 2, followed by a horizontal translation of the graph of f by -8 units

(B) A horizontal dilation of the graph of f by a factor of 2, followed by a horizontal translation of the graph of f by 8 units

(C) A horizontal dilation of the graph of f by a factor of $\frac{1}{2}$, followed by a horizontal translation of the graph of f by -4 units

(D) A horizontal dilation of the graph of f by a factor of $\frac{1}{2}$, followed by a horizontal translation of the graph of f by 4 units

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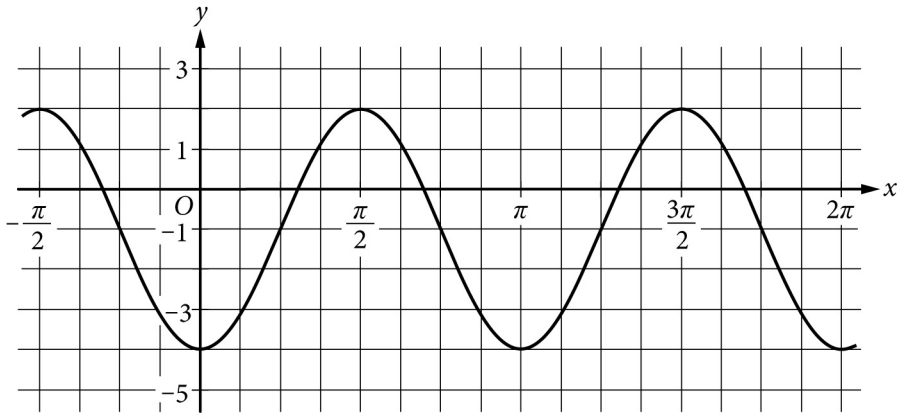

Graph of f

20. The figure shows the graph of a trigonometric function f. Which of the following could be an expression for $f(x)$?

(A) $3\cos\left(2\left(x-\frac{\pi}{4}\right)\right)-1$

(B) $3\cos\left(2\left(x-\frac{\pi}{8}\right)\right)-1$

(C) $3\sin\left(2\left(x-\frac{\pi}{4}\right)\right)-1$

(D) $3\sin\left(2\left(x-\frac{\pi}{8}\right)\right)-1$

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21. Let f be a rational function that is graphed in the xy-plane. Consider $x = 1$ and $x = 7$. The polynomial in the numerator of f has a zero at $x = 1$ and does not have a zero at $x = 7$. The polynomial in the denominator of f has zeros at both $x = 1$ and $x = 7$. The multiplicities of the zeros at $x = 1$ in the numerator and in the denominator are equal. Which of the following statements is true?

(A) The graph of f has holes at both $x = 1$ and $x = 7$.

(B) The graph of f has a vertical asymptote at $x = 1$ and a hole at $x = 7$.

(C) The graph of f has a hole at $x = 1$ and a vertical asymptote at $x = 7$.

(D) The graph of f has vertical asymptotes at both $x = 1$ and $x = 7$.

t (months)	0	1	2	3	4
$P(t)$ (thousands)	20	30	45	67.5	101.25

22. The increasing function P gives the number of followers, in thousands, for a new musical group on a social media site. The table gives values of $P(t)$ for selected values of t, in months, since the musical group created their account on this social media site. If a model is constructed to represent these data, which of the following best applies to this situation?

(A) $y = 10t + 20$

(B) $y = \frac{325}{16}t + 20$

(C) $y = 20\left(\frac{2}{3}\right)^t$

(D) $y = 20\left(\frac{3}{2}\right)^t$

GO ON TO THE NEXT PAGE.

23. The polynomial function k is given by $k(x) = ax^4 - bx^3 + 15$, where a and b are nonzero real constants. Each of the zeros of k has multiplicity 1. In the xy-plane, an x-intercept of the graph of k is $(17.997, 0)$. A zero of k is $-0.478 - 0.801i$. Which of the following statements must be true?

(A) The graph of k has three x-intercepts.

(B) $-0.478 + 0.801i$ is a zero of k.

(C) The equation $k(x) = 0$ has four real solutions.

(D) The graph of k is tangent to the x-axis at $x = 17.997$.

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24. Consider the functions f and g given by $f(x) = \log_{10}(x-1) + \log_{10}(x+3)$ and $g(x) = \log_{10}(x+9)$. In the xy-plane, what are all x-coordinates of the points of intersection of the graphs of f and g ?

(A) $x = 3$ only

(B) $x = 7$

(C) $x = -4$ and $x = 3$

(D) $x = -7$ and $x = -4$

GO ON TO THE NEXT PAGE.

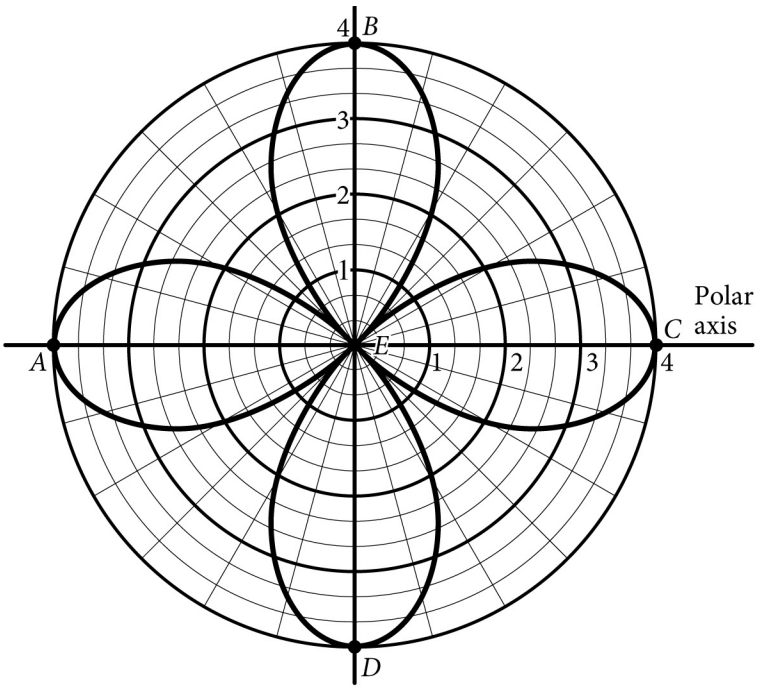
25. What are all values of θ, for $0 \le \theta < 2\pi$, where $2\sin^2\theta = -\sin\theta$?

(A) $0, \pi, \frac{\pi}{6}$, and $\frac{5\pi}{6}$

(B) $0, \pi, \frac{7\pi}{6}$, and $\frac{11\pi}{6}$

(C) $\frac{\pi}{2}, \frac{3\pi}{2}, \frac{\pi}{3}$, and $\frac{5\pi}{3}$

(D) $\frac{\pi}{2}, \frac{3\pi}{2}, \frac{2\pi}{3}$, and $\frac{4\pi}{3}$



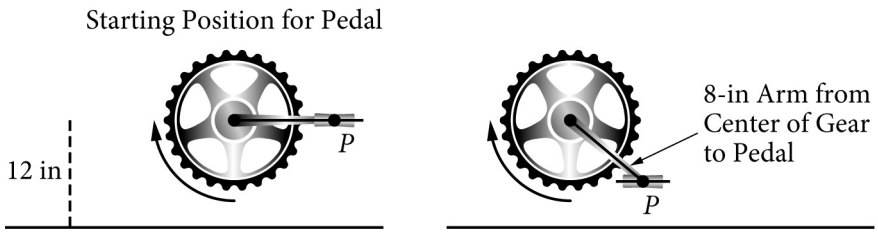
26. The figure shows the graph of the polar function $r = f(\theta)$, where $f(\theta) = 4\cos(2\theta)$, in the polar coordinate system for $0 \le \theta \le 2\pi$. There are five points labeled A, B, C, D, and E. If the domain of f is restricted to $0 \le \theta \le \frac{\pi}{2}$, the portion of the given graph that remains consists of two pieces. One of those pieces is the portion of the graph in Quadrant I from C to E. Which of the following describes the other remaining piece?

(A) The portion of the graph in Quadrant I from E to B

(B) The portion of the graph in Quadrant II from E to A

(C) The portion of the graph in Quadrant III from E to A

(D) The portion of the graph in Quadrant III from E to D



27. A physical therapy center has a bicycle that patients use for exercise. The height, in inches (in), of the bicycle pedal above level ground periodically increases and decreases when used. The figure gives the position of the pedal P at a height of 12 inches above the ground at time $t = 0$ seconds. The pedal's 8-inch arm defines the circular motion of the pedal. If a patient pedals 1 revolution per second, which of the following could be an expression for $h(t)$, the height, in inches, of the bicycle pedal above level ground at time t seconds?

(A) $8 - 12\sin t$

(B) $12 - 8\sin t$

(C) $8 - 12\sin(2\pi t)$

(D) $12 - 8\sin(2\pi t)$

28. Consider the graph of the polar function $r = f(\theta)$, where $f(\theta) = 1 + 2\sin\theta$, in the polar coordinate system for $0 \le \theta \le 2\pi$. Which of the following statements is true about the distance between the point with polar coordinates $\big(f(\theta), \theta\big)$ and the origin?

(A) The distance is increasing for $0 \le \theta \le \dfrac{\pi}{2}$, because $f(\theta)$ is positive and increasing on the interval.

(B) The distance is increasing for $\dfrac{3\pi}{2} \le \theta \le \dfrac{11\pi}{6}$, because $f(\theta)$ is negative and increasing on the interval.

(C) The distance is decreasing for $0 \le \theta \le \dfrac{\pi}{2}$, because $f(\theta)$ is positive and decreasing on the interval.

(D) The distance is decreasing for $\dfrac{3\pi}{2} \le \theta \le \dfrac{11\pi}{6}$, because $f(\theta)$ is negative and decreasing on the interval.

END OF PART A

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.

PART B BEGINS ON PAGE 22.

PRECALCULUS

SECTION I, Part B

Time—40 minutes

Number of questions—12

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

Directions: Solve each of the following problems, using the available space for scratch work. After examining the choices, decide which is the best of the choices given and fill in the corresponding circle on the answer sheet. No credit will be given for anything written in this exam booklet. Do not spend too much time on any one problem.

BE SURE YOU FILL IN THE CIRCLES ON THE ANSWER SHEET THAT CORRESPOND TO QUESTIONS NUMBERED 76–87.

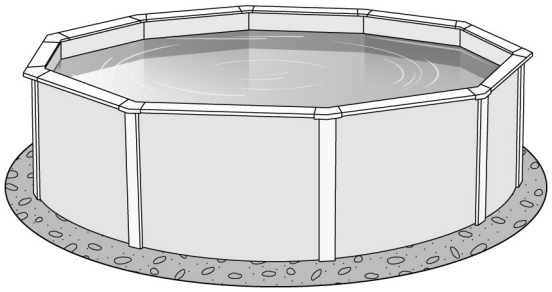
YOU MAY NOT RETURN TO QUESTIONS NUMBERED 1–28.

In this exam:

(1) The exact numerical value of the correct answer does not always appear among the choices given. When this happens, select from among the choices the number that best approximates the exact numerical value.

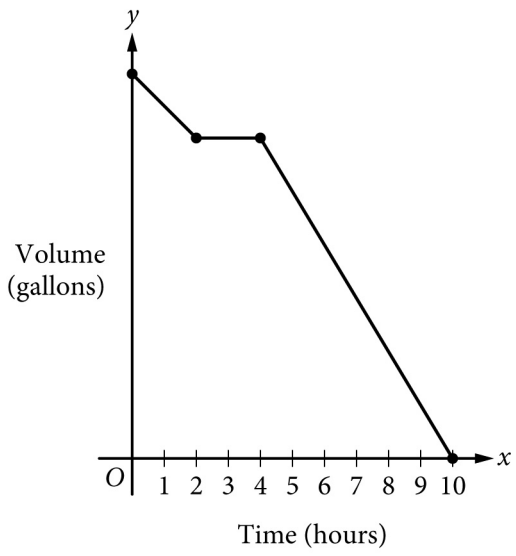
(2) Unless otherwise specified, the domain of a function f is assumed to be the set of all real numbers x for which $f(x)$ is a real number.

(3) Angle measures for trigonometric functions are assumed to be in radians. **Make sure your calculator is in radian mode.**



76. The figure shows a swimming pool filled with water. A pump is used to remove water from the pool until the pool is empty. When the pump is running, the rate at which the volume of water in the pool decreases is constant. During the first two hours, the pump works slower than usual due to a broken piece. Then the pump stops working. The broken piece is replaced, and the pump works at its usual rate until the pool is completely emptied of water. The entire process of emptying the pool takes six hours. Which of the following graphs could depict this situation, where time, in hours, is the independent variable, and the volume of water in the pool, in gallons, is the dependent variable?

(A)



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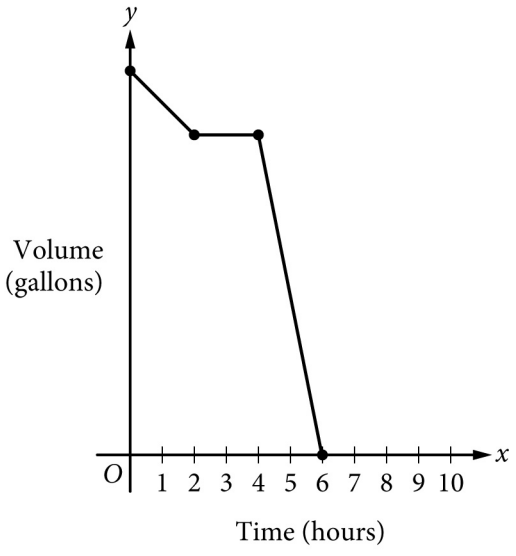

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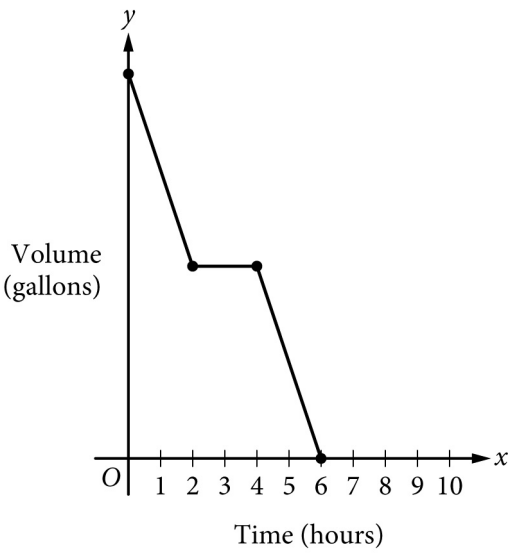

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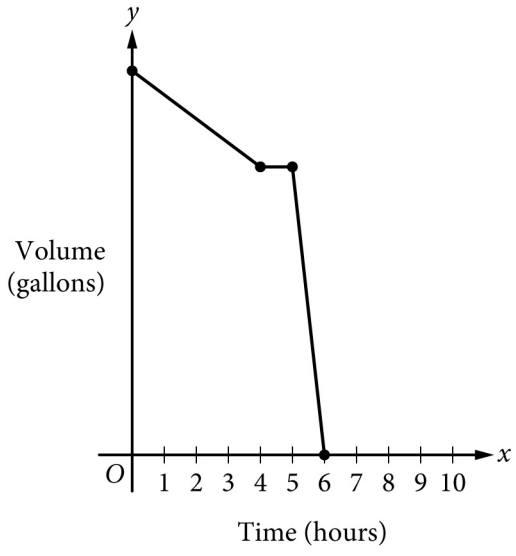

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77. In a certain simulation, the population of a bacteria colony can be modeled using a geometric sequence, where the first day of the simulation is day 1. The population on day 4 was 4,000 bacteria, and the population on day 8 was 49,000 bacteria. What was the population of the colony on day 6 based on the simulation?

(A) 26,500

(B) 26,192

(C) 14,000

(D) 611

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78. The rate of people entering a subway car on a particular day is modeled by the function R, where $R(t) = 0.03t^3 - 0.846t^2 + 6.587t + 1.428$ for $0 \le t \le 20$. $R(t)$ is measured in people per hour, and t is measured in hours since the subway began service for the day. Based on the model, at what value of t does the rate of people entering the subway car change from increasing to decreasing?

(A) $t = 20$

(B) $t = 17.056$

(C) $t = 13.295$

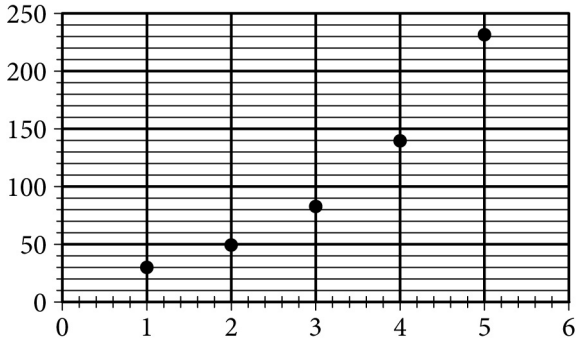
(D) $t = 5.505$

GO ON TO THE NEXT PAGE.

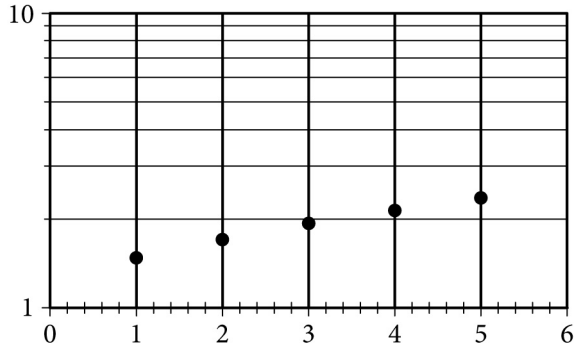
t	1	2	3	4	5
$m(t)$	30	50	83	139	231

79. The table gives values for a function m at selected values of t. Which of the following graphs could represent these data in a semi-log plot, where the vertical axis is logarithmically scaled?

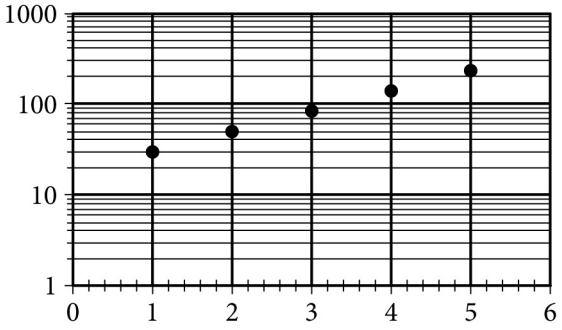
(A)



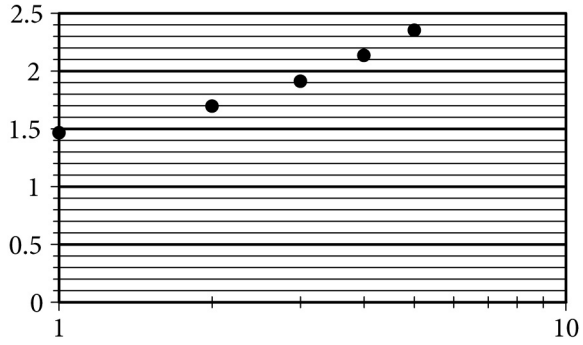
(B)



(C)



(D)



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80. At a coastal city, the height of the tide, in feet (ft), is modeled by the function h, defined by $h(t) = 6.3\cos\left(\frac{\pi}{6}t\right) + 7.5$ for $0 \le t \le 12$ hours. Based on the model, which of the following is true?

(A) The maximum height of the tide is 13.8 ft.

(B) The maximum height of the tide occurs at $t = 6$ hours.

(C) The minimum height of the tide is 1 ft.

(D) The minimum height of the tide occurs at $t = 12$ hours.

---

81. The function f is defined by $f(x) = a\sin\big(b(x+c)\big) + d$, for constants a, b, c, and d. In the xy-plane, the points $(2,2)$ and $(4,4)$ represent a minimum value and a maximum value, respectively, on the graph of f. What are the values of a and d ?

(A) $a = 1$ and $d = 3$

(B) $a = 1$ and $d = 2$

(C) $a = 2$ and $d = 3$

(D) $a = 2$ and $d = 2$

82. The function S is given by $S(t)=\frac{500{,}000}{1+0.4e^{kt}}$, where k is a constant. If $S(4)=300{,}000$, what is the value of $S(12)$?

(A) 175,325

(B) 214,772

(C) 343,764

(D) 357,143

---

83. Two function models k and m are constructed to represent the sales of a product at a group of grocery stores. Both $k(t)$ and $m(t)$ represent the sales of the product, in thousands of units, after t weeks for $t \geq 2$. If $k(t)=14-2.885\ln t$ and $m(t)=-t+14$, what is the first time t that sales predicted by the logarithmic model will be 0.1 thousand units more than sales predicted by the linear model?

(A) $t=6.318$

(B) $t=4.324$

(C) $t=3.577$

(D) $t=2.289$

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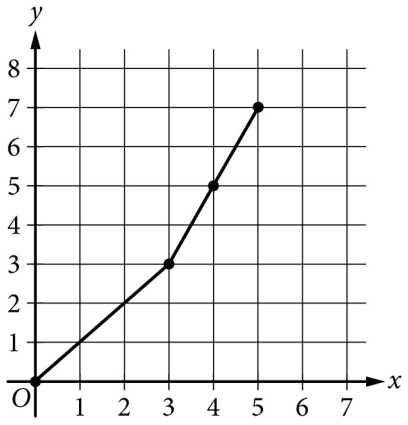
84. The function f is given by $f(x) = 2\sin(4x) + \cos(2x)$. Using the period of f, which of the following is the number of complete cycles of the graph of f in the xy-plane on the interval $0 \le x \le 1000$?

(A) 159

(B) 318

(C) 602

(D) 636



Graph of f

85. The graph of the piecewise-linear function f is shown in the figure. Let g be the inverse function of f. What is the maximum value of g ?

(A) $\frac{1}{7}$

(B) $\frac{1}{5}$

(C) 5

(D) 7

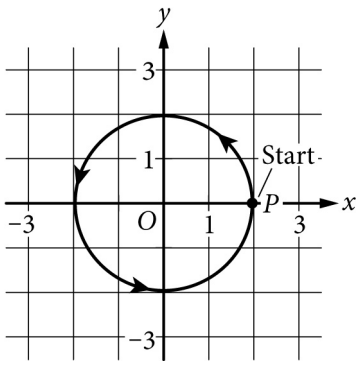
86. The function f is given by $f(x) = \sin(2.25x + 0.2)$. The function g is given by $g(x) = f(x) + 0.5$. What are the zeros of g on the interval $0 \le x \le \pi$?

(A) 1.085 and 2.481

(B) 1.307 and 2.704

(C) 1.540 and 2.471

(D) 0.144, 1.075, and 2.936



87. A large wheel of radius 2 feet is rotated at a constant rate. The figure provides a representation of the wheel in the xy-plane with the direction of rotation indicated. At time $t = 0$ minutes, the wheel begins to rotate. Point P on the wheel is at the "Start" position in the figure. At time $t = 20$ minutes, 120 rotations of the wheel have been completed, and P is in the same position as it was at time $t = 0$. A sinusoidal function is used to model the y-coordinate of the position of P as a function of time t in minutes. Which of the following functions is an appropriate model for this situation?

(A) $f(t) = 2\sin\left(\frac{\pi}{10}t\right)$

(B) $f(t) = 2\sin\left(\frac{\pi}{3}t\right)$

(C) $f(t) = 2\sin(6t)$

(D) $f(t) = 2\sin(12\pi t)$

END OF SECTION I

IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY CHECK YOUR WORK ON PART B ONLY.

DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

NO TEST MATERIAL ON THIS PAGE.

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Answer Key and Question Alignment to Course Framework

Multiple-Choice Question	Answer	Skill	Learning Objective	Essential Knowledge
1	D	1.A	1.5.A	1.5.A.3
2	D	1.B	2.4.A	2.4.A.2
3	A	2.A	1.1.B	1.1.B.4
4	B	3.A	1.6.A	1.6.A.3
5	A	1.B	2.12.A	2.12.A.2
6	A	3.A	1.5.A	1.5.A.1
7	D	1.C	1.9.A	1.9.A.1
8	C	2.A	3.7.A	3.7.A.1
9	A	1.C	1.12.A	1.12.A.5
10	D	3.C	2.3.A	2.3.A.1
11	C	1.B	2.7.B	2.7.B.2
12	D	3.C	1.3.B	1.3.B.2
13	A	1.B	3.12.B	3.12.B.3
14	B	2.B	2.14.A	2.14.A.2
15	A	1.B	3.13.A	3.13.A.4
16	D	3.C	3.2.A	3.2.A.3
17	B	3.C	1.12.A	1.12.A.3
18	A	2.A	2.7.A	2.7.A.2
19	D	3.A	1.12.A	1.12.A.5
20	C	2.B	3.6.A	3.6.A.6
21	C	2.A	1.11.A	1.11.A.1
22	D	1.C	2.5.A	2.5.A.4
23	B	3.A	1.5.A	1.5.A.4
24	A	1.A	2.13.A	2.13.A.2
25	B	1.A	3.10.A	3.10.A.1
26	D	3.A	3.14.A	3.14.A.2
27	D	1.C	3.7.A	3.7.A.2
28	A	3.C	3.15.A	3.15.A.1
76	B	2.B	1.1.B	1.1.B.2
77	C	3.B	2.2.B	2.2.B.3
78	D	3.B	1.4.A	1.4.A.2
79	C	2.B	2.15.A	2.15.A.1
80	A	3.A	3.7.A	3.7.A.5
81	A	2.A	3.7.A	3.7.A.2
82	A	3.B	2.13.A	2.13.A.1
83	B	3.B	2.14.A	2.14.A.6
84	B	3.B	3.7.A	3.7.A.1
85	C	2.A	2.8.B	2.8.B.3
86	C	1.A	3.10.A	3.10.A.2
87	D	1.C	3.7.A	3.7.A.1