Practice Exam

Exam Content and Format

The AP Precalculus Exam is three hours long. There are two sections:

- Section I is multiple-choice questions. It is two hours long and is divided into two Parts: A and B. Part A is one hour and 20 minutes and consists of 28 multiple-choice questions, accounting for 43.75 percent of the final score. Part B is 40 minutes and consists of 12 multiple-choice questions, accounting for 18.75 percent of the final score.
- Section II is free-response questions. It is one hour long and is divided into two Parts: A and B. Part A is 30 minutes and consists of two free-response questions. Part B is 30 minutes and consists of two free-response questions. Part A and B each account for 18.75 percent of the final score.

Administering the Practice Exam

This section contains instructions for administering the AP Precalculus Practice Exam. The AP Precalculus Practice Exam should be administered after completion of Units 1, 2, and 3. You may wish to use these instructions to create an exam environment that resembles an actual administration, so that your students have some familiarity with the experience prior to the day of the exam. If so, read the indented, boldface directions to the students; all other instructions are for administering the exam and need not be read aloud. Before beginning testing, have all exam materials ready for distribution. These include test booklets and answer sheets. (Reminder: Final instructions for every AP Exam are published in the *AP Exam Instructions* book.)

Calculator Use

Graphing calculators are required to answer some of the questions on the AP Precalculus Exam. Before starting the exam administration, make sure each student has a graphing calculator from the approved list on the "AP-Approved Graphing Calculators" table in **Part 2** of the *2023-24 AP Coordinator's Manual*. Note that a subset of the full list of approved calculators has the expected built-in capabilities for AP Precalculus.

During the administration of Section I, Part B, and Section II, Part A, students may have **no more than two** graphing calculators on their desks. Nongraphing scientific calculators are not permitted as a second calculator. Calculators may not be shared. **Calculator memories do not need to be cleared before or after the exam**. Students with Hewlett-Packard 48-50 Series and Casio FX-9860 graphing calculators may use cards designed for use with these calculators. Proctors should make sure infrared ports (Hewlett-Packard) are not facing each other.

Since graphing calculators can be used to store data, including text, proctors should monitor that students are using their calculators appropriately. Attempts by students to use the calculator to remove exam questions and/or answers from the room may result in the cancellation of AP Exam scores.

Section I: Multiple Choice

Before starting the exam administration, make sure each student has an appropriate calculator for the exam. See details in the section above. Calculators are **not** permitted for Section I: Part A.

During an actual AP Exam administration, students will seal the Part A section after the time for Part A has ended. You may choose to have students seal the Part A section OR you may collect the Part A section from students before they begin the Part B section.

When you are ready to begin Section I, say:

> **Section I is the multiple-choice portion of the exam. You must complete the answer sheet using a No. 2 pencil only. Mark all of your responses on your answer sheet, one response per question. If you need to erase, do so carefully and completely. Scratch paper is not allowed, but you may use the margins or any blank space in the exam booklet for scratch work. Your score on the multiple-choice section will be based solely on the number of questions answered correctly.**
>
> **Section I is divided into two parts, A and B. Each part is timed separately, and you may work on each part only during the time allotted for it. Calculators are not allowed in Part A. Please put your calculators under your chair.**
>
> **Are there any questions?**
>
> **You have one hour and 20 minutes for Part A. Part A questions are numbered 1 through 28. Mark your responses on your answer sheet. Do not go on to Part B until instructed to do so. Once final time is called for Part A, stop working immediately.**
>
> **Now open your Section I booklet and begin.**

Note Start Time _____. Note Stop Time _____.

Check that students are marking their answers in pencil on their answer sheets and that they are not looking beyond Part A. The line of A's that run along the top of each page in Part A will assist you in monitoring students' work.

After 1 hour and 10 minutes, say:

> **There are 10 minutes remaining.**

After 10 more minutes, say:

> **Stop working on Part A.**

Read the appropriate information from the boxes.

If you are distributing seals to students for the Part A section, say:

> **Turn to page ___ in your Section I booklet. Making sure all of your other exam materials, including your answer sheet, are out of the way, take a seal and press it on the middle of the page and then fold the seal over the open edge to the front cover. Be sure you don't seal the Part B section of the booklet.**

If you are collecting the Part A section of the exam booklet, say:

> **I will now collect your Part A Section I booklet.**

After all students have sealed Part A OR you have collected the Part A booklets, say:

> **Turn to Part B, which starts on page ____. Graphing calculators are required for Part B, so get your calculators from under your chair and place them on your desk. Part B questions are numbered 76 through 87. You have 40 minutes for Part B. Once final time is called for Part B, stop working immediately. You may begin.**

Note Start Time _____. Note Stop Time _____.

Check that students have sealed their Part A booklets properly OR have turned in their Part A booklets, and are now working on Part B. The large B's that run along the top of the page in an alternating shaded pattern will assist you in monitoring their work. Make sure that students are using their calculators appropriately. You should also make sure Hewlett-Packard calculators' infrared ports are not facing each other and that students are not sharing calculators.

After 30 minutes, say:

> **There are 10 minutes remaining.**

After 10 more minutes, say:

> **Stop working. Close your exam booklet and put your answer sheet face-up on your desk. I will now collect your Section I booklet and multiple-choice answer sheet.**

There is a 10-minute break between Sections I and II.

> **Please listen carefully to these instructions before we take a 10-minute break. Please put all of your calculators under your chair. Your calculators and all items you placed under your chair must stay there. You are not permitted to open or access them in any way. You are not allowed to consult teachers, other students, notes, textbooks, or any other resources during the break. You may not make phone calls, send text messages, use your calculators, check email, use a social networking site, or access any electronic or communication device. You may not leave the designated break area.**
>
> **You may begin your break now. Testing will resume at _____.**

Section II: Free Response

During an actual AP Exam administration, Part B of the Section II Free-Response Questions booklet will be sealed. You may choose to create exam booklets where the Part B section has a seal OR you may direct students not to turn to Part B at any point during their completion of Part A.

After the break, say:

> **Section II is the free-response portion of the exam. For this section of the exam, you will use a pen with black or dark blue ink or a No. 2 pencil to write your responses. Does everyone have a pen or pencil? . . .**
>
> **You should now have in front of you the Free-Response Questions booklet, which I will call the Questions booklet for short, and the Free-Response Answer booklet, which I will call the Answer booklet for short, where you'll write your responses.**

First, look at the cover of the Questions booklet, paying careful attention to the bulleted statements in the instructions. Do not open any booklets until you are told to do so. Look up when you have finished. . . .

Are there any questions? . . .

Graphing calculators are required for Part A, so make sure your calculators are on your desk now.

Section II has two parts, A and B, that are timed separately. You have 30 minutes to answer the two questions in Part A. You are responsible for pacing yourself and may proceed freely from Question 1 to Question 2 in Part A.

If you placed a seal on the Part B pages of the Free-Response Questions booklet, say:

Do not break the seal for Part B until you are told to do so.

If you did not seal the Part B pages of the Free-Response Questions booklet, say:

Do not open the Part B section until you are told to do so.

You may make notes in the Questions booklet. No credit will be given for any work written in that booklet. You must write your responses in the Answer booklet. If you use a pencil, be sure that your writing is dark enough to be easily read.

Show your work and write your response to each question part on the correct designated page in the Answer booklet. Numbers across the top of the page indicate which question to answer on the page.

If you run out of space, raise your hand.

Once final time is called for Part A, stop working immediately.

Are there any questions? . . .

Now open your Section II booklets and begin.

Note Start Time _____. Note Stop Time _____.

Make sure students are working on Part A only and writing their responses in their Free-Response Answer Booklet, **not** in their Free-Response Questions booklet. The pages for the Part A questions are marked with large 1's or 2's along the top of each page to assist you in monitoring their work.

Make sure that students are using their calculators appropriately. You should also make sure that Hewlett-Packard calculators' infrared ports are not facing each other and that students are not sharing calculators.

If a student runs out of space and raises their hand, give them extra paper.

After 20 minutes, say:

There are 10 minutes remaining.

After 10 more minutes, say:

Stop working on Part A. Calculators are not allowed for Part B. Please put all of your calculators under your chair. . . .

Turn to page _____ in the Questions booklet and turn to page _____ in the Answer booklet. You have 30 minutes for Part B. During this time you may go back to Part A, but you may not use your calculator. Remember to

show your work and write your response to each question on the correct designated page and part in the Answer booklet. Once final time is called for Part B, stop working immediately. Are there any questions? . . .

If you placed a seal on the Part B pages of the Free-Response Questions booklet, say:

Using your finger, break open the seal on Part B in the Questions booklet. You may go on to the next page and begin Part B.

If you did not seal the Part B pages of the Free-Response Questions booklet, say:

You may go on to the next page and begin Part B.

Note Start Time _____. Note Stop Time _____.

After 20 minutes, say:

There are 10 minutes remaining in Part B.

After 10 more minutes, say:

Stop working and close both booklets. Place them faceup on your desk. Keep your booklets separate; don't put one inside the other. . . .

If any students used extra paper for a question in the free-response section, have those students staple the extra sheet(s) to the first page corresponding to that question in their Free-Response Answer booklets.

Then say:

Remain in your seat, without talking, while the exam materials are collected.

Collect a Free-Response Questions booklet and Free-Response Answer booklet from each student. Check that each student wrote responses in their Free-Response Answer booklet and not in the Questions booklet.

Then say:

The exam is over. You are now dismissed.

Answer Sheet for AP Precalculus
Practice Exam, Section I

No.	Answer	No.	Answer
1		76	
2		77	
3		78	
4		79	
5		80	
6		81	
7		82	
8		83	
9		84	
10		85	
11		86	
12		87	
13			
14			
15			
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17			
18			
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21			
22			
23			
24			
25			
26			
27			
28			

AP® Precalculus Exam

SECTION I: Multiple Choice

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
2 hours
Number of Questions
40
Percent of Total Score
62.5%
Writing Instrument
Pencil required

Part A

Number of Questions
28
Time
1 hour and 20 minutes
Electronic Device
None allowed

Part B

Number of Questions
12
Time
40 minutes
Electronic Device
Graphing calculator required

Instructions

Section I of this exam contains 40 multiple-choice questions.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice section is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

PRECALCULUS

SECTION I, Part A

Time—1 hour and 20 minutes

28 Questions

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. Consider the functions g and h given by $g(x) = 4^x$ and $h(x) = 16^{x+2}$. In the xy-plane, what is the x-coordinate of the point of intersection of the graphs of g and h ?

(A) -4

(B) -2

(C) 0

(D) 2

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2. The function f is given by $f(x) = \log_2 x$. What input value in the domain of f yields an output value of 4 ?

(A) 32

(B) 16

(C) 2

(D) $\frac{1}{2}$

3. The function k is given by $k(\theta) = 2\sin\theta$. What are all values of θ, for $0 \le \theta < 2\pi$, where $k(\theta) = -1$?

(A) $\theta = \frac{\pi}{6}$ and $\theta = \frac{5\pi}{6}$

(B) $\theta = \frac{\pi}{3}$ and $\theta = \frac{5\pi}{3}$

(C) $\theta = \frac{2\pi}{3}$ and $\theta = \frac{4\pi}{3}$

(D) $\theta = \frac{7\pi}{6}$ and $\theta = \frac{11\pi}{6}$

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4. Which of the following expressions is equivalent to $\log_3(x^5)$?

(A) $\log_3 5 + \log_3 x$

(B) $\log_3 5 \cdot \log_3 x$

(C) $5\log_3 x$

(D) $\frac{\log_3 x}{\log_3 5}$

5. Which of the following statements is true about the exponential function h given by $h(x) = -3 \cdot 4^x$?

(A) h is always increasing, and the graph of h is always concave up.

(B) h is always increasing, and the graph of h is always concave down.

(C) h is always decreasing, and the graph of h is always concave up.

(D) h is always decreasing, and the graph of h is always concave down.

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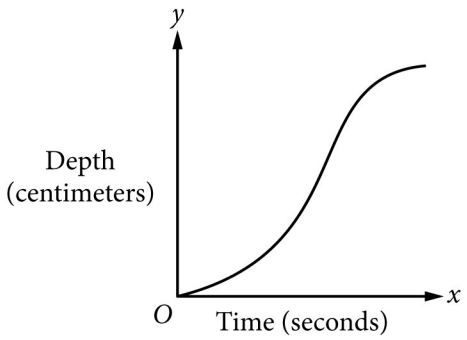
6. In the xy-plane, the graph of a rational function f has a hole at $x = 2$. Input values of f sufficiently close to 2 correspond to output values arbitrarily close to 6. Which of the following could define $f(x)$?

(A) $f(x) = \dfrac{6(x-2)(x+3)}{(x-3)(x-2)}$

(B) $f(x) = \dfrac{(x-2)(x+4)}{(x-2)(x-1)}$

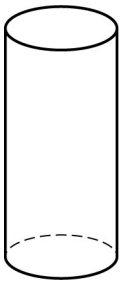
(C) $f(x) = \dfrac{(x-6)(x+4)}{(x-6)(x-1)}$

(D) $f(x) = \dfrac{(x+1)(x+6)}{(x-1)(x+2)}$

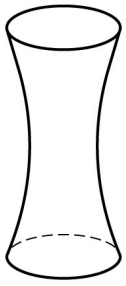


7. At time $t = 0$, water begins pouring into an empty container at a constant rate. The water pours into the container until it is full. The situation is modeled by the given graph, where time, in seconds, is the independent variable and the depth of water in the container, in centimeters, is the dependent variable. For which of the following containers would the graph be appropriate?

(A)



(B)



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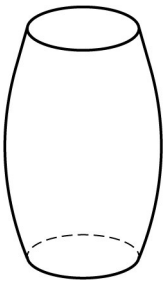
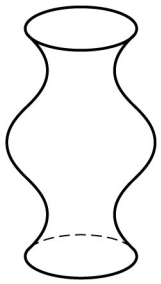


(D)



8. At time $t = 0$ years, the population of a certain city was 23,144. During each of the next 10 years, the population decreased by 4% per year. Based on this information, which of the following models the population as a function of time t, in years, for $0 \le t \le 10$?

(A) $23{,}144 - 0.04t$

(B) $23{,}144 - 0.96t$

(C) $23{,}144\left(0.96\right)^t$

(D) $23{,}144\left(1.04\right)^t$

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9. Where both expressions are defined, which of the following is equivalent to $\frac{\sec^2 x - 1}{\sec^2 x}$?

(A) $\frac{\tan^2 x}{\sin^2 x}$

(B) $\frac{\tan^2 x}{\cos^2 x}$

(C) $\sin^2 x$

(D) $\cos^2 x$

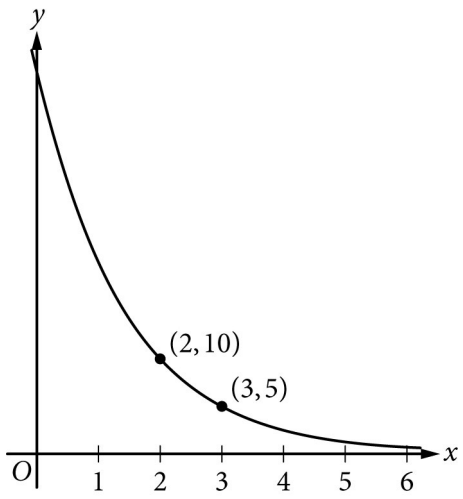
10. The location of point X in polar coordinates (r, θ) is $\left(1, \frac{5\pi}{6}\right)$. Which of the following describes the location of point X in rectangular coordinates (x, y) ?

(A) $\left(-\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

(B) $\left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

(C) $\left(\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$

(D) $\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$



Graph of f

11. The figure shows the graph of an exponential decay function f. The coordinates of two of the points are labeled. If $y = f(x)$, what is the y-coordinate of the point on the graph where $x = 0$?

(A) 40

(B) 30

(C) 20

(D) 15

x	$g(x)$
-1	-3
0	-2
1	1
2	6
3	13

12. The table gives values for a function g at selected values of x. Which of the following statements is true?

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

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

(C) g is best modeled by a linear function, because the successive 2nd differences of the output values over equal-interval input values are constant.

(D) g is best modeled by a quadratic function, because the successive 2nd differences of the output values over equal-interval input values are constant.

13. The function f is given by $f(t) = e^t$, and the function g is given by $g(t) = 7 \ln t$. If the function h is given by $h(t) = (f \circ g)(t)$, which of the following is an expression for $h(t)$, for $t > 0$?

(A) $7t$

(B) t^7

(C) te^7

(D) 7^t

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14. The binomial theorem can be used to expand the polynomial function p, given by $p(x) = (x - 3)^5$. What is the coefficient of the x^3 term in the expanded polynomial?

(A) $(-3)^3 \cdot 10$

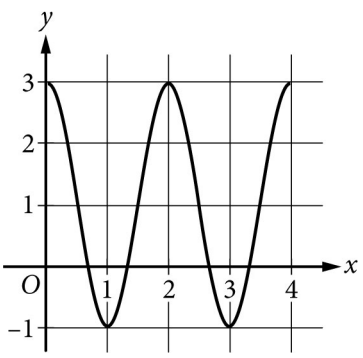
(B) $(-3)^2 \cdot 10$

(C) $(-3)^3 \cdot 5$

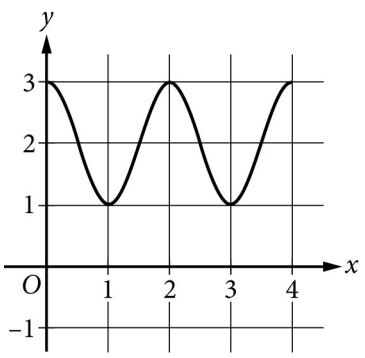
(D) $(-3)^2 \cdot 5$

15. The function g is given by $g(x) = 2\cos(\pi x) + 1$. Which of the following is the graph of g for $0 \le x \le 4$?

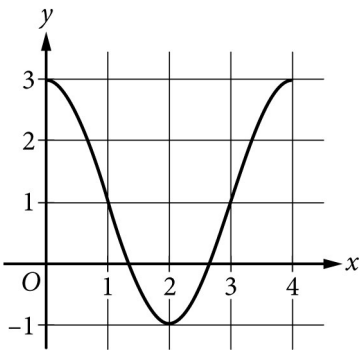
(A)



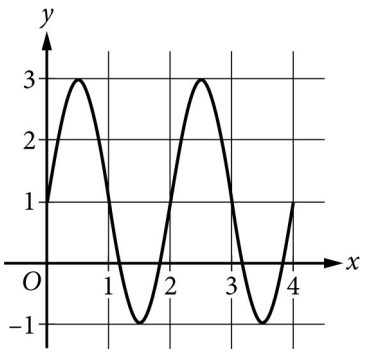
(B)

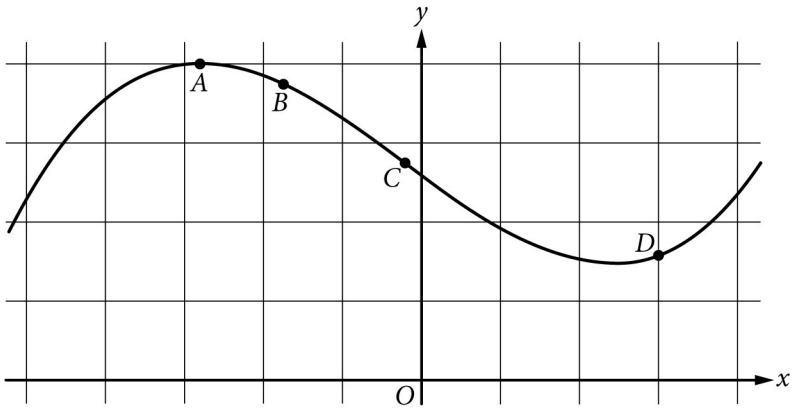


(C)



(D)





Graph of g

16. The figure shows the graph of a function g in the xy-plane with four labeled points. It is known that a relative maximum of g occurs at A, and the only point of inflection of the graph of g is C. Of the following points, at which is the rate of change of g the least?

(A) A

(B) B

(C) C

(D) D

Point	A	B	C	D
r	2	2	–2	–2
θ	$-\frac{\pi}{4}$	$-\frac{3\pi}{4}$	$\frac{5\pi}{4}$	$\frac{7\pi}{4}$

17. The table gives polar coordinates (r, θ) for four selected points. Which of the points lies in Quadrant II of the xy-plane?

(A) A, because from the positive y-axis, $\frac{\pi}{4}$ counterclockwise is in Quadrant II, and the radius is positive.

(B) B, because from the positive x-axis, $\frac{3\pi}{4}$ clockwise is in Quadrant II, and the radius is positive.

(C) C, because from the positive x-axis, $\frac{5\pi}{4}$ counterclockwise is in Quadrant III, and the negative radius indicates a reflection over the x-axis.

(D) D, because from the positive x-axis, $\frac{7\pi}{4}$ counterclockwise from the origin is in Quadrant IV, and the negative radius indicates the opposite direction of the angle from the origin.

18. The amount of water used each day in an office building, measured in hundreds of gallons, is modeled by the function g defined by $g(t) = 5\sin\left(0.8\left(t+2\right)\right) + 25$, for integer values of t with $0 \le t \le 365$ days. Using actual data over time, it was determined that the model underestimates the amount of water used each day by 800 gallons. Based on this information, which of the following functions is a better model for the amount of water used each day, measured in hundreds of gallons?

(A) $f(t) = 5\sin\left(0.8\left(t+10\right)\right) + 25$

(B) $h(t) = 5\sin\left(0.8\left(t+2\right)\right) + 33$

(C) $k(t) = 5\sin\left(6.4\left(t+2\right)\right) + 25$

(D) $m(t) = 40\sin\left(0.8\left(t+2\right)\right) + 25$

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19. In the xy-plane, two different angles α and β are in standard position and share a terminal ray. Based on this information, which of the following gives possible values for α and β ?

(A) $\alpha = -\frac{\pi}{4}$ and $\beta = -\frac{7\pi}{4}$

(B) $\alpha = \frac{3\pi}{5}$ and $\beta = -\frac{3\pi}{5}$

(C) $\alpha = \frac{2\pi}{3}$ and $\beta = \frac{8\pi}{3}$

(D) $\alpha = \frac{5\pi}{6}$ and $\beta = -\frac{\pi}{6}$

20. In the xy-plane, the function h, given by $h(x) = 3^{(x+2)}$, is a horizontal translation of the exponential function f, given by $f(x) = 3^x$. Which of the following is an equivalent form for $h(x)$ that expresses h as a vertical dilation of f ?

(A) $h(x) = 3^{(x/2)}$

(B) $h(x) = 9 \cdot 3^x$

(C) $h(x) = 9 \cdot \left(\frac{1}{3}\right)^x$

(D) $h(x) = 9 + 3^x$

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x	3	4	5	6	7
$g(x)$	-11	-19	-29	-41	-55

21. The table gives values for a polynomial function g at selected values of x. If $a < b$, then $g(a) > g(b)$ for all a and b in the interval $3 < x < 7$. Which of the following could be true about the graph of g on the interval $3 < x < 7$?

(A) The graph of g is concave down because the function is decreasing, and the average rate of change over equal-length input-value intervals is increasing.

(B) The graph of g is concave up because the function is decreasing, and the average rate of change over equal-length input-value intervals is increasing.

(C) The graph of g is concave down because the function is decreasing, and the average rate of change over equal-length input-value intervals is decreasing.

(D) The graph of g is concave up because the function is decreasing, and the average rate of change over equal-length input-value intervals is decreasing.

22. The function f is given by $f(x) = 2\cos(\pi x) + 3$. The graph of f is mapped to the graph of g in the same xy-plane by a horizontal translation of the graph of f by $\frac{\pi}{2}$ units right. Which of the following is an expression for $g(x)$?

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

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

(C) $2\cos(\pi x) + 3 - \frac{\pi}{2}$

(D) $2\cos(\pi x) + 3 + \frac{\pi}{2}$

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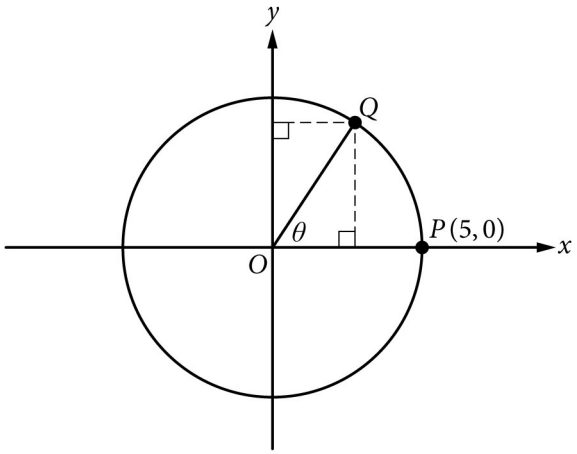
23. The function C models temperature, in degrees Celsius, as a function of time t, in hours, for $t \geq 0$. The function P models electricity usage, in kilowatts, as a function of temperature, in degrees Celsius. Let K be the composition function defined by $K(t) = P(C(t))$. Which of the following statements is true about function K ?

(A) K models electricity usage as a function of time.

(B) K models temperature as a function of electricity usage.

(C) K models time as a function of electricity usage.

(D) K models electricity usage as a function of temperature.



Note: Figure not drawn to scale.

24. The figure shows a circle centered at the origin with an angle of measure θ radians in standard position and point P on the circle. The terminal ray of the angle intersects the circle at point Q. The length of arc $\widehat{PQ}$ is 6 units. Which of the following gives the distance of point Q from the y-axis?

(A) $\cos\left(\frac{6}{5}\right)$

(B) $\sin\left(\frac{6}{5}\right)$

(C) $5\cos\left(\frac{6}{5}\right)$

(D) $5\sin\left(\frac{6}{5}\right)$

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25. In the xy-plane, the graph of which of the following functions has a vertical asymptote at $x = \frac{3\pi}{4}$?

(A) $f(x) = \cot x$

(B) $f(x) = \cot\left(x - \frac{\pi}{2}\right)$

(C) $f(x) = \cot\left(x - \frac{\pi}{4}\right)$

(D) $f(x) = \cot\left(x + \frac{\pi}{4}\right)$

26. The function r is given by $r(x) = \dfrac{x^2 - x - 2}{(x+1)^2(x-2)}$. In the xy-plane, which of the following is true about holes in the graph of r ?

(A) There are holes at $x = -1$ and $x = 2$ because the multiplicity of -1 in the denominator is greater than the multiplicity of -1 in the numerator, and because the multiplicity of 2 in the numerator is equal to the multiplicity of 2 in the denominator.

(B) There are holes at $x = -1$ and $x = 2$ because the multiplicity of -1 in the numerator is equal to the multiplicity of -1 in the denominator, and because the multiplicity of 2 in the numerator is equal to the multiplicity of 2 in the denominator.

(C) There is a hole at $x = 2$ only because the multiplicity of -1 in the denominator is greater than the multiplicity of -1 in the numerator, and because the multiplicity of 2 in the numerator is equal to the multiplicity of 2 in the denominator.

(D) There is a hole at $x = 2$ only because the multiplicity of -1 in the numerator is equal to the multiplicity of -1 in the denominator, and because the multiplicity of 2 in the numerator is equal to the multiplicity of 2 in the denominator.

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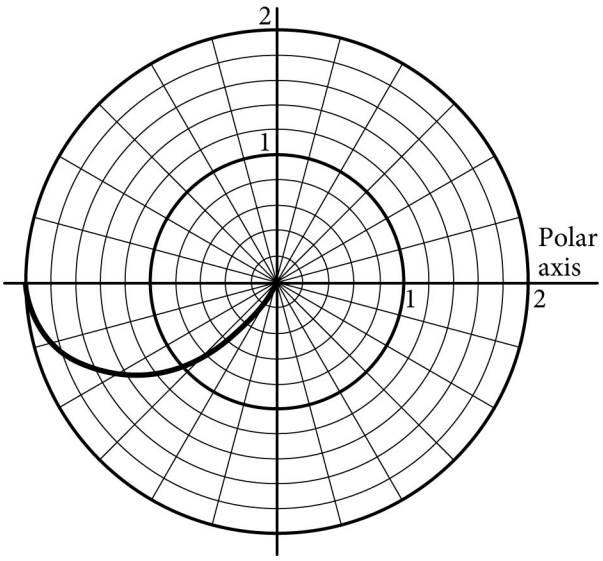
27. A regression model S is constructed for a data set. The residuals from the regression are plotted and labeled. Based on the vertical axis of the residual plot (not shown), point A is located at 1.3 and point B is located at -2.5. Which of the following statements is true about the model and the estimates produced by the model that correspond to A and B ?

(A) The model produces an overestimate at A and an underestimate at B. Based on the absolute values of the residuals, there is a greater error in the model with B than with A.

(B) The model produces an underestimate at A and an overestimate at B. Based on the absolute values of the residuals, there is a greater error in the model with B than with A.

(C) The model produces an overestimate at A and an underestimate at B. Based on the absolute values of the residuals, there is a greater error in the model with A than with B.

(D) The model produces an underestimate at A and an overestimate at B. Based on the absolute values of the residuals, there is a greater error in the model with A than with B.



28. A portion of the graph of the polar function $r = f(\theta)$, where $f(\theta) = 2 - 4\cos\theta$, is shown in the polar coordinate system for $a \le \theta \le b$. If $0 \le a < b < 2\pi$, which of the following are the values for a and b ?

(A) $a = 0$ and $b = \frac{\pi}{3}$

(B) $a = 0$ and $b = \frac{\pi}{6}$

(C) $a = \pi$ and $b = \frac{4\pi}{3}$

(D) $a = \pi$ and $b = \frac{7\pi}{6}$

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.

NO TEST MATERIAL ON THIS PAGE.

PART B BEGINS ON PAGE 23.

PRECALCULUS

SECTION I, Part B

Time—40 minutes

12 Questions

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.**

x	0	1	2	3	4
$f(x)$	18	16	6	0	10

76. The table gives values for a polynomial function f at selected values of x. What is the average rate of change of f over the closed interval $[1, 4]$?

(A) -2

(B) $-\frac{1}{2}$

(C) 2

(D) 13

Year (time t)	Length of High-Speed Railways (thousands of kilometers)
2010 $(t = 0)$	1
2013 $(t = 3)$	7
2016 $(t = 6)$	16
2019 $(t = 9)$	25
2022 $(t = 12)$	38

77. The table shows the length of high-speed railways, in thousands of kilometers, in a certain country, starting in the year 2010 $(t = 0)$. A quartic regression is used to model the length of high-speed railways as a function of years since 2010. What length of high-speed railways, in thousands of kilometers, is predicted by the model for 2028 $(t = 18)$?

(A) 54.2

(B) 127.0

(C) 309.3

(D) 942.1

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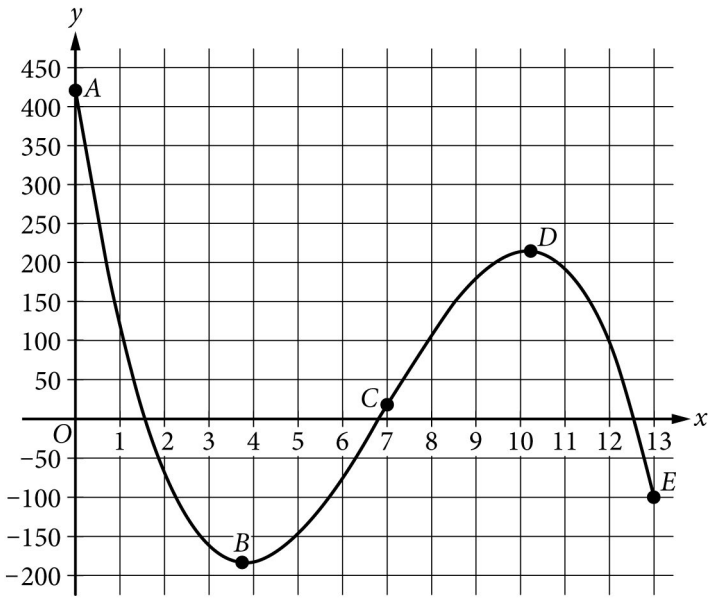

Graph of g

78. The figure shows the graph of function g for $0 \le x \le 13$. The endpoints of the interval are labeled with points A and E. Two other extrema for g are labeled with points B and D. Point C is the only point of inflection of the graph of g for $0 \le x \le 13$. Let t_A, t_B, t_C, t_D, and t_E represent the x-coordinates at those points. Of the following, on which intervals is the rate of change of g decreasing?

(A) $[t_A, t_B]$ only

(B) $[t_D, t_E]$ only

(C) $[t_A, t_B]$ and $[t_D, t_E]$

(D) $[t_C, t_D]$ and $[t_D, t_E]$

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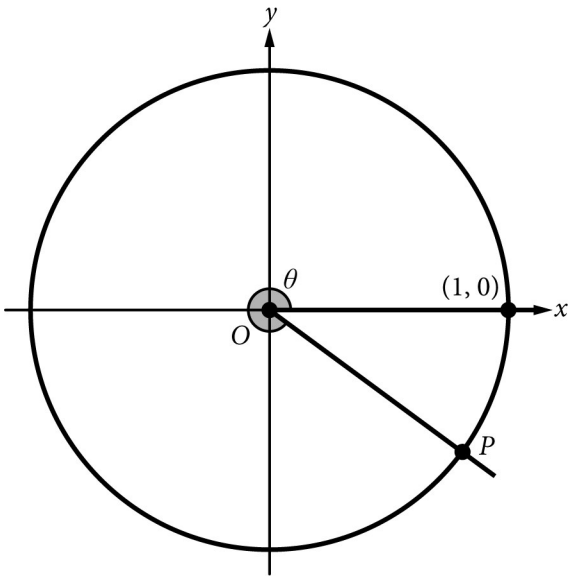

79. The figure shows a circle centered at the origin with an angle of measure θ radians in standard position. The terminal ray of the angle intersects the circle at point P. If $\tan\theta = -\frac{3}{4}$, what is the slope of the line that passes through the origin and P ?

(A) $-\frac{4}{3}$

(B) $-\frac{4}{5}$

(C) $-\frac{3}{4}$

(D) $-\frac{3}{5}$

B B B B B B B B B

80. A set of data is represented using a semi-log plot (not shown), in which the vertical axis is logarithmically scaled. The points on the semi-log plot appear to follow a decreasing linear pattern. Which of the following function types best models the set of data?

(A) Linear

(B) Exponential growth

(C) Exponential decay

(D) Logarithmic

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B B B B B B B B B

81. The function C models the cost, in dollars, for producing x items and is given by $C(x) = \frac{1000 + bx}{x}$, where b is a constant. It is known that the cost is \$115 to produce 10 items and \$65 to produce 20 items. What is the average rate of change of C as x changes from $x = 30$ to $x = 40$?

(A) −\$0.83 per item

(B) −\$5 per item

(C) −\$8.33 per item

(D) −\$50 per item

---

82. For time t hours, $0 \le t \le 2$, the number of people inside a large shopping center is changing at a rate modeled by the function P given by $P(t) = t^3 - 4t^2 + 3t + 1$, where $P(t)$ is measured in hundreds of people per hour. Which of the following gives the time t and reasoning for when the number of people inside the shopping center is at its maximum?

(A) $t = 0.451$, because the rate of change in the number of people inside the shopping center changes from increasing to decreasing.

(B) $t = 0.451$, because the rate of change in the number of people inside the shopping center changes from positive to negative.

(C) $t = 1.445$, because the rate of change in the number of people inside the shopping center changes from increasing to decreasing.

(D) $t = 1.445$, because the rate of change in the number of people inside the shopping center changes from positive to negative.

x	-5.1	-5.01	-5.001	-5	-4.999	-4.99	-4.9
$f(x)$	-10	-100	-1000	undefined	1000	100	10

83. The table gives values for a rational function f at selected values of x. The polynomial in the numerator and the polynomial in the denominator of the function have no zeros in common. Based on the information given, which of the following conclusions is possible for the graph of f in the xy-plane?

(A) The graph of f has an x-intercept at $x = -5$.

(B) The graph of f has a hole at $x = -5$.

(C) The graph of f has a vertical asymptote at $x = -5$.

(D) The graph of f has a horizontal asymptote at $y = -5$.

---

x (years)	1.5	2	2.5	3	4	6
y (pounds)	2420	3150	3615	4105	4835	6355

84. The table gives the weight y, in pounds, of an animal for selected ages x, in years. A logarithmic regression is used to model these data. What is the weight of the animal, to the nearest pound, predicted by the logarithmic function model at age 4.5 years?

(A) 5073

(B) 5203

(C) 5333

(D) 5345

85. The polar function $r = f(\theta)$, where $f(\theta) = 1 + 2\cos\theta$, is graphed in the polar coordinate system for $0 \le \theta \le 2\pi$. On which of the following intervals of θ is the distance between the point with polar coordinates $(f(\theta), \theta)$ and the origin decreasing?

(A) $(0, 2.094)$ only

(B) $(2.094, 4.189)$

(C) $(0, 2.094)$ and $(3.142, 4.189)$

(D) $(2.094, 3.142)$ and $(4.189, 6.283)$

---

86. On a given day, the number of people, in thousands, that have entered a museum is modeled by the function h given by $h(t) = 4.217\tan^{-1}(0.7t - 0.026)$, where t is measured in hours and $0 \le t \le 8$. Based on the model, at what time t did person number 4000 enter the museum?

(A) $t = 1.121$

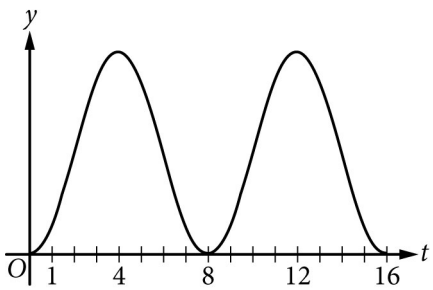
(B) $t = 2.029$

(C) $t = 5.165$

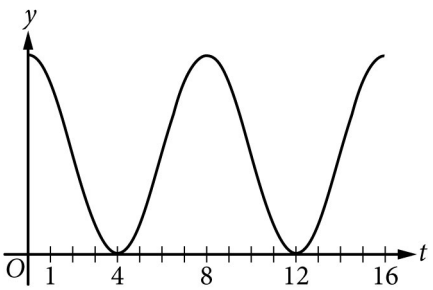
(D) $t = 6.623$

87. For $0 \le t \le 16$, the rate at which customers arrive at a restaurant on a given day is modeled by the function R, where $R(t)$ is measured in customers per hour and t is measured in hours since the restaurant opened. The function R is increasing for $0 < t < 4$ and $8 < t < 12$, and R is decreasing for $4 < t < 8$ and $12 < t < 16$. The function N models the total number of customers who have arrived at the restaurant since it opened, up to time t. Which of the following could be the graph of $y = N(t)$ for $0 \le t \le 16$?

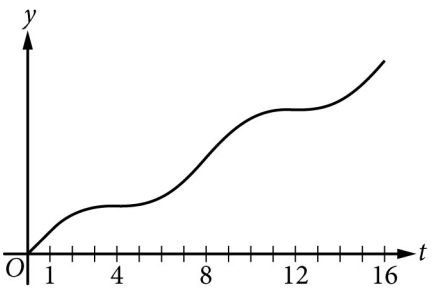
(A)



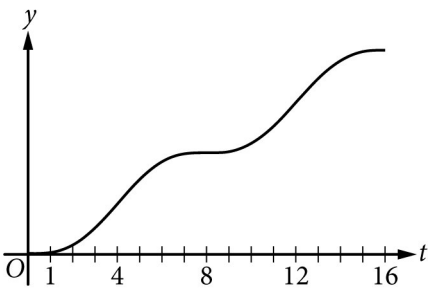
(B)



(C)



(D)



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.