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**Please note: Some of the questions in this former practice exam may no longer perfectly align with the AP exam. Even though these questions do not fully represent the 2020 exam, teachers indicate that imperfectly aligned questions still provide instructional value. Teachers can consult the Question Bank to determine the degree to which these questions align to the 2020 Exam.**

**This exam may not be posted on school or personal websites, nor electronically redistributed for any reason.** This exam is provided by the College Board for AP Exam preparation. Teachers are permitted to download the materials and make copies to use with their students in a classroom setting only. To maintain the security of this exam, teachers should collect all materials after their administration and keep them in a secure location.

**Further distribution of these materials outside of the secure College Board site disadvantages teachers who rely on uncirculated questions for classroom testing.** Any additional distribution is in violation of the College Board's copyright policies and may result in the termination of Practice Exam access for your school as well as the removal of access to other online services such as the AP Teacher Community and Online Score Reports.

## SECTION II: Free Response

After the break, say:

**May I have everyone's attention? Place your Student Pack on your desk. . . .**

**You may now remove the shrinkwrap from the Section II packet, but do not open the Section II exam booklet until you are told to do so. . . .**

Read the bulleted statements on the front cover of the exam booklet. Look up when you have finished. . . .

Now take an AP number label from your Student Pack and place it on the shaded box. If you don't have any AP number labels, write your AP number in the box. Look up when you have finished. . . .

Read the last statement. . . .

Using a pen with black or dark blue ink, print the first, middle, and last initials of your legal name in the boxes and print today's date where indicated. This constitutes your signature and your agreement to the statements on the front cover. . . .

Turn to the back cover and, using your pen, complete Item 1 under "Important Identification Information." Print the first two letters of your last name and the first letter of your first name in the boxes. Look up when you have finished. . . .

In Item 2, print your date of birth in the boxes. . . .

In Item 3, write the school code you printed on the front of your Student Pack in the boxes. . . .

Read Item 4. . . .

Are there any questions? . . .

I need to collect the Student Pack from anyone who will be taking another AP Exam. You may keep it only if you are not taking any other AP Exams this year. If you have no other AP Exams to take, place your Student Pack under your chair now. . . .

Read the information on the back cover of the exam booklet, paying careful attention to the bulleted statements in the instructions. Do not open the exam booklet or break the seals in the exam booklet until you are told to do so. Look up when you have finished. . . .

Collect the Student Packs. Then say:

Are there any questions? . . .

Section II also has two parts that are timed separately. You are responsible for pacing yourself and may proceed freely from one question to the next within each part. Graphing calculators are required for Part A, so you may keep your calculators on your desk. You must write your answers in the appropriate space in the exam booklet using a No. 2 pencil or a pen with black or dark blue ink. Do not break the seals for Part B at this time.

Are there any questions? . . .

You have 30 minutes to answer the questions in Part A. If you need more paper during the exam, raise your hand. At the top of each extra sheet of paper you use, be sure to write only your AP number and the question

**number you are working on. Do not write your name. Open your exam booklet and begin.**



Note Start Time here \_\_\_\_\_. Note Stop Time here \_\_\_\_\_. Check that students are working on Part A only and writing their answers in their exam booklets using pencils or pens with black or dark blue ink. The pages for the Part A questions are marked with large 1's or 2's at the top of each page to assist you in monitoring their work. After 20 minutes, say:

**There are 10 minutes remaining in Part A.**

After 10 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 13. You have 1 hour 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 answer to each part of each problem in the appropriate space in the exam booklet. Are there any questions? . . .**

**Using your finger, break open the seals on Part B. Do not peel the seals away from the booklet. You may go on to the next page and begin Part B.**



Note Start Time here \_\_\_\_\_. Note Stop Time here \_\_\_\_\_. After 50 minutes, say:

**There are 10 minutes remaining in Part B.**

After 10 minutes, say:

**Stop working and close your exam booklet. Place it on your desk, face up. . . .**

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 exam booklets. Complete an Incident Report. A single Incident Report may be completed for multiple students per exam subject per administration (regular or late testing) as long as all of the required information is provided. Include all exam booklets with extra sheets of paper in an Incident Report return envelope (see page 62 of the *2016-17 AP Coordinator's Manual* for complete details). Then say:

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

Collect a Section II exam booklet from each student. Check for the following:

- Exam booklet front cover: The student placed an AP number label on the shaded box and printed his or her initials and today's date.
- Exam booklet back cover: The student completed the "Important Identification Information" area.

When all exam materials have been collected and accounted for, return to students any electronic devices you may have collected before the start of the exam.

*If you are giving the regularly scheduled exam, say:*

**You may not discuss or share the free-response exam content with anyone unless it is released on the College Board website in about two days. Your AP Exam score results will be available online in July.**

*If you are giving the alternate exam for late testing, say:*

**None of the content in this exam may ever be discussed or shared in any way at any time. Your AP Exam score results will be available online in July.**

If any students completed the AP number card at the beginning of this exam, say:

**Please remember to take your AP number card with you. You will need the information on this card to view your scores and order AP score reporting services online.**

Then say:

**You are now dismissed.**

### Post-Exam Tasks

Be sure to give the completed seating chart to the AP coordinator. Schools must retain seating charts for at least six months (unless the state or district requires that they be retained for a longer period of time). Schools should not return any seating charts in their exam shipments unless they are required as part of an Incident Report.

The exam proctor should complete the following tasks if asked to do so by the AP coordinator. Otherwise, the AP coordinator must complete these tasks.

All exam materials must be placed in secure storage until they are returned to the AP Program after your school's last administration. Before storing materials, check the "School Use Only" section on page 1 of the answer sheet and:

- Fill in the appropriate section number circle in order to access a separate AP Instructional Planning Report (for regularly scheduled exams only) or subject score roster at the class section or teacher level. See "Post-Exam Activities" in the *2016-17 AP Coordinator's Manual*.
- Check your list of students who are eligible for fee reductions and fill in the appropriate circle on their registration answer sheets.

# AP<sup>®</sup> Calculus AB Exam

## SECTION II: Free Response

2017

DO NOT OPEN THIS BOOKLET OR BREAK THE SEALS ON PART B UNTIL YOU ARE TOLD TO DO SO.

### At a Glance

**Total Time**

1 hour and 30 minutes

**Number of Questions**

6

**Percent of Total Score**

50%

**Writing Instrument**

Either pencil or pen with black or dark blue ink

**Weight**

The questions are weighted equally, but the parts of a question are not necessarily given equal weight.

### Part A

**Number of Questions**

2

**Time**

30 minutes

**Electronic Device**

Graphing calculator required

**Percent of Section II Score**

33.33%

### Part B

**Number of Questions**

4

**Time**

1 hour

**Electronic Device**

None allowed

**Percent of Section II Score**

66.67%

### IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name

First letter of your first name

2. Date of birth

Month Day Year

3. Six-digit school code

4. Unless I check the box below, I grant the College Board the unlimited right to use, reproduce, and publish my free-response materials, both written and oral, for educational research and instructional purposes. My name and the name of my school will not be used in any way in connection with my free-response materials. I understand that I am free to mark "No" with no effect on my score or its reporting.

No, I do not grant the College Board these rights. ☐

### Instructions

The questions for Section II are printed in this booklet. Do not break the seals on Part B until you are told to do so. Write your solution to each part of each question in the space provided. Write clearly and legibly. Cross out any errors you make; erased or crossed-out work will not be scored.

Manage your time carefully. During Part A, work only on the questions in Part A. You are permitted to use your calculator to solve an equation, find the derivative of a function at a point, or calculate the value of a definite integral. However, you must clearly indicate the setup of your question, namely the equation, function, or integral you are using. If you use other built-in features or programs, you must show the mathematical steps necessary to produce your results. During Part B, you may continue to work on the questions in Part A without the use of a calculator.

As you begin each part, you may wish to look over the questions before starting to work on them. It is not expected that everyone will be able to complete all parts of all questions.

- Show all of your work, even though a question may not explicitly remind you to do so. Clearly label any functions, graphs, tables, or other objects that you use. Justifications require that you give mathematical reasons, and that you verify the needed conditions under which relevant theorems, properties, definitions, or tests are applied. Your work will be scored on the correctness and completeness of your methods as well as your answers. Answers without supporting work will usually not receive credit.
- Your work must be expressed in standard mathematical notation rather than calculator syntax. For example,  $\int_1^5 x^2 dx$  may not be written as `fnInt(X2, X, 1, 5)`.
- Unless otherwise specified, answers (numeric or algebraic) need not be simplified. If you use decimal approximations in calculations, your work will be scored on accuracy. Unless otherwise specified, your final answers should be accurate to three places after the decimal point.
- 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.

Form I

Form Code 4NBP4-S

66

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

**A GRAPHING CALCULATOR IS REQUIRED FOR THESE QUESTIONS.**

1. A particle moves along the  $x$ -axis so that its velocity at time  $t$  is given by  $v(t) = \frac{t^6 - 13t^4 + 12}{10t^3 + 3}$ . At time

$t = 0$ , the initial position of the particle is  $x = 7$ .

(a) Find the acceleration of the particle at time  $t = 5.1$ .

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(b) Find all values of  $t$  in the interval  $0 \leq t \leq 2$  for which the speed of the particle is 1.

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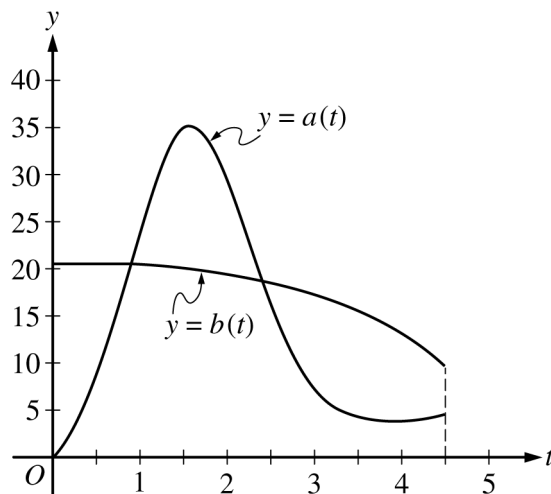
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- (c) Find the position of the particle at time  $t = 4$ . Is the particle moving toward the origin or away from the origin at time  $t = 4$ ? Justify your answer.

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- (d) During the time interval  $0 < t \leq 4$ , does the particle return to its initial position? Give a reason for your answer.

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2. During the time interval  $0 \leq t \leq 4.5$  hours, water flows into tank  $A$  at a rate of  $a(t) = (2t - 5) + 5e^{2\sin t}$  liters per hour. During the same time interval, water flows into tank  $B$  at a rate of  $b(t)$  liters per hour. Both tanks are empty at time  $t = 0$ . The graphs of  $y = a(t)$  and  $y = b(t)$ , shown in the figure above, intersect at  $t = k$  and  $t = 2.416$ .

(a) How much water will be in tank  $A$  at time  $t = 4.5$  ?

- 
- (b) During the time interval  $0 \leq t \leq k$  hours, water flows into tank  $B$  at a constant rate of 20.5 liters per hour. What is the difference between the amount of water in tank  $A$  and the amount of water in tank  $B$  at time  $t = k$  ?

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- (c) The area of the region bounded by the graphs of  $y = a(t)$  and  $y = b(t)$  for  $k \leq t \leq 2.416$  is 14.470. How much water is in tank  $B$  at time  $t = 2.416$  ?

- 
- (d) During the time interval  $2.7 \leq t \leq 4.5$  hours, the rate at which water flows into tank  $B$  is modeled by

$$w(t) = 21 - \frac{30t}{(t-8)^2} \text{ liters per hour. Is the difference } w(t) - a(t) \text{ increasing or decreasing at time}$$

$t = 3.5$  ? Show the work that leads to your answer.

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**END OF PART A**

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

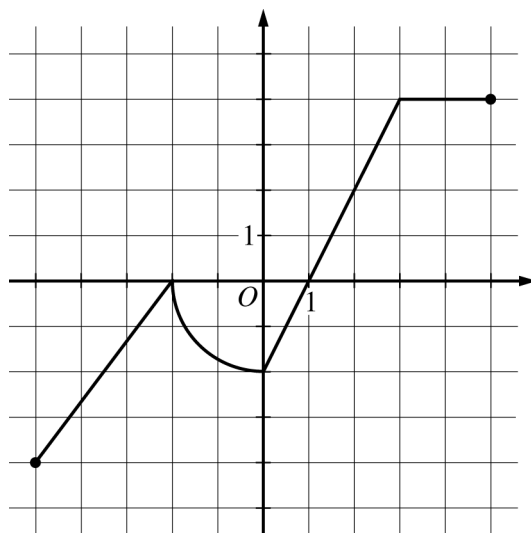
**DO NOT GO ON TO PART B UNTIL YOU ARE TOLD TO DO SO.**

**CALCULUS AB**  
**SECTION II, Part B**  
**Time—1 hour**  
**Number of questions—4**

**NO CALCULATOR IS ALLOWED FOR THESE QUESTIONS.**

**DO NOT BREAK THE SEALS UNTIL YOU ARE TOLD TO DO SO.**

## NO CALCULATOR ALLOWED

Graph of  $f$ 

3. The graph of the function  $f$ , consisting of three line segments and a quarter of a circle, is shown above. Let  $g$  be the function defined by  $g(x) = \int_1^x f(t) dt$ .

(a) Find the average rate of change of  $g$  from  $x = -5$  to  $x = 5$ .

(b) Find the instantaneous rate of change of  $g$  with respect to  $x$  at  $x = 3$ , or state that it does not exist.

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**NO CALCULATOR ALLOWED**

(c) On what open intervals, if any, is the graph of  $g$  concave up? Justify your answer.

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(d) Find all  $x$ -values in the interval  $-5 < x < 5$  at which  $g$  has a critical point. Classify each critical point as the location of a local minimum, a local maximum, or neither. Justify your answers.

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## NO CALCULATOR ALLOWED

$x$	0	1	2	3	4	5	6
$f'(x)$	4	3.5	2	0.8	1.7	5.8	7

4. The function  $f$  satisfies  $f(0) = 20$ . The first derivative of  $f$  satisfies the inequality  $0 \leq f'(x) \leq 7$  for all  $x$  in the closed interval  $[0, 6]$ . Selected values of  $f'$  are shown in the table above. The function  $f$  has a continuous second derivative for all real numbers.

- (a) Use a midpoint Riemann sum with three subintervals of equal length indicated by the data in the table to approximate the value of  $f(6)$ .

- (b) Determine whether the actual value of  $f(6)$  could be 70. Explain your reasoning.

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## NO CALCULATOR ALLOWED

(c) Evaluate  $\int_2^4 f''(x) \, dx$ .

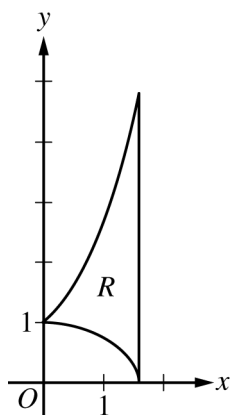
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(d) Find  $\lim_{x \rightarrow 0} \frac{f(x) - 20e^x}{0.5f(x) - 10}$ .

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## NO CALCULATOR ALLOWED



5. Let  $R$  be the region in the first quadrant enclosed by the graph of  $f(x) = \sqrt{\cos x}$ , the graph of  $g(x) = e^x$ , and the vertical line  $x = \frac{\pi}{2}$ , as shown in the figure above.

(a) Write, but do not evaluate, an integral expression that gives the area of  $R$ .

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## NO CALCULATOR ALLOWED

- (b) Find the volume of the solid generated when  $R$  is revolved about the  $x$ -axis.

- 
- (c) Region  $R$  is the base of a solid whose cross sections perpendicular to the  $x$ -axis are semicircles with diameters on the  $xy$ -plane. Write, but do not evaluate, an integral expression that gives the volume of this solid.

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## NO CALCULATOR ALLOWED

6. For  $0 \leq t \leq 6$  seconds, a screen saver on a computer screen shows two circles that start as dots and expand outward.
- (a) At the instant that the first circle has a radius of 9 centimeters, the radius is increasing at a rate of  $\frac{3}{2}$  centimeters per second. Find the rate at which the area of the circle is changing at that instant. Indicate units of measure.

- 
- (b) The radius of the first circle is modeled by  $w(t) = 12 - 12e^{-0.5t}$  for  $0 \leq t \leq 6$ , where  $w(t)$  is measured in centimeters and  $t$  is measured in seconds. At what time  $t$  is the radius of the circle increasing at a rate of 3 centimeters per second?

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## NO CALCULATOR ALLOWED

- (c) A model for the radius of the second circle is given by the function  $f$  for  $0 \leq t \leq 6$ , where  $f(t)$  is measured in centimeters and  $t$  is measured in seconds. The rate of change of the radius of the second circle is given by  $f'(t) = t^2 - 4t + 4$ . Based on this model, by how many centimeters does the radius of the second circle increase from time  $t = 0$  to  $t = 3$  ?

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