AP

Advanced Placement Program®

1998 AP® CALCULUS AB
EXAMINATION

The College Board
Educational Excellence for All Students

Advanced Placement Program®
THE COLLEGE BOARD

AREA 1 – COMPLETE THIS AREA AT EVERY EXAMINATION.

A. SIGNATURE

To maintain the security of the exam and the validity of my AP grade, I will allow no one other than myself to see the multiple-choice questions and will seal the appropriate section when asked to do so. In addition, I am aware of and agree to the Program's policies and procedures as outlined in the 1998 AP Bulletin for Students and Parents.

Sign your name as it will appear on your college applications.

PLACE AP® NUMBER LABEL HERE.

B. YOUR AP NUMBER

C. NAME

Omit spaces, hyphens, apostrophes, Jr. or II.

Last Name - first 15 letters   First Name - first 12 letters   MI

D. ADMIN. DAY IN MAY

E. TIME OF DAY

- 6 AM
- 7 AM
- 8 AM
- 9 AM
- 10 AM
- 11 AM
- 12 PM
- 1 PM
- 2 PM
- 3 PM
- 4 PM
- 5 PM

F. AP EXAMINATION TO BE TAKEN USING THIS ANSWER SHEET

Print examination name:

Fill in the appropriate oval below for examination name and number.

07 U.S. History	55 German Language
13 Art: History of	57 Gov. & Pol.: U.S.
14 Art: Studio Drawing	58 Gov. & Pol.: Comp.
15 Art: Studio General	59 International English Language
20 Biology	60 Latin: Vergil
25 Chemistry	60 Latin: Literature
31 Computer Science A	66 Calculus AB
33 Computer Science AB	68 Calculus BC
34 Economics: **Micro**	75 Music Theory
35 Economics: **Macro**	78 Physics B
36 Eng. Language & Comp.	80 Physics C: **Mech.**
37 Eng. Literature & Comp.	80 Physics C: **E & M**
40 Environmental Science	85 Psychology
43 European History	87 Spanish Language
48 French Language	89 Spanish Literature
51 French Literature	90 Statistics

AREA 2 – COMPLETE THIS AREA ONLY ONCE.

I. SEX
- (1) Male
- (2) Female

J. PRESENT GRADE LEVEL
- (1) 9th grade
- (2) 10th grade
- (3) 11th grade
- (4) 12th grade
- (5) College
- (6) Other

K. DATE OF BIRTH

Month   Day   Year

- 01 Jan.
- 02 Feb.
- 03 Mar.
- 04 Apr.
- 05 May
- 06 June
- 07 July
- 08 Aug.
- 09 Sept.
- 10 Oct.
- 11 Nov.
- 12 Dec.

L. SOCIAL SECURITY NUMBER

M. ETHNIC GROUP
- (1) American Indian or Alaskan native
- (2) Black or African American
- (3) Mexican American or Chicano
- (4) Asian, Asian American, or Pacific Islander
- (5) Puerto Rican
- (6) South American, Latin American, Central American, or other Hispanic
- (7) White
- (8) Other

N. EXPECTED DATE OF COLLEGE ENTRANCE
- (f) Fall
- (w) Winter/Spring
- (s) Summer
- (u) Undecided

- (8) 1998
- (9) 1999
- (0) 2000
- (1) 2001

O. Will you be applying for Sophomore Standing at college?
- ○ Yes
- ○ No

P. STUDENT SEARCH SERVICE OF THE COLLEGE BOARD
(Complete ONLY if you are a SOPHOMORE or a JUNIOR.)

- ○ Yes, I want the College Board to send information about me to colleges, universities, and governmental scholarship programs interested in students like me.

- ○ No, I do not want the College Board to send information about me to colleges, universities, and governmental scholarship programs through the Student Search Service.

G. What language do you know best?
- ○ English
- ○ English and another language about the same
- ○ Another language

H. DO NOT COMPLETE THIS SECTION UNLESS INSTRUCTED TO DO SO.

Essay Choices
Fill in the ovals under the numbers of the essay questions you answered in this examination.

1 2 3 4 5 6 7 8 9 10 11 12

ETS USE ONLY

Exam   Exam

SCHOOL USE ONLY

Fee Reduction Granted

Report to Teachers Section Designation

I.N. 240045   18002 • 00657 • TF18M1300   Q2800-06   CHW97329   1   2   3   4

Q. THIS SECTION IS FOR THE SURVEY QUESTIONS IN THE CANDIDATE PACK. (DO NOT PUT RESPONSES TO EXAM QUESTIONS IN THIS SECTION.) BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL.

1 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   4 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   5 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

DO NOT COMPLETE THIS SECTION UNLESS INSTRUCTED TO DO SO.

R. If this answer sheet is for the French Language, French Literature, German Language, Spanish Language, or Spanish Literature Examination, please answer the following questions. (Your responses will not affect your grade.)

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken? ◯ Yes   ◯ No

2. Do you regularly speak or hear the language at home? ◯ Yes   ◯ No

INDICATE YOUR ANSWERS TO THE EXAM QUESTIONS IN THIS SECTION. IF A QUESTION HAS ONLY FOUR ANSWER OPTIONS, DO NOT MARK OPTION (E). YOUR ANSWER SHEET WILL BE SCORED BY MACHINE. USE ONLY NO. 2 PENCILS TO MARK YOUR ANSWERS ON PAGES 2 AND 3 (ONE RESPONSE PER QUESTION). AFTER YOU HAVE DETERMINED YOUR RESPONSE, BE SURE TO COMPLETELY FILL IN THE OVAL CORRESPONDING TO THE NUMBER OF THE QUESTION YOU ARE ANSWERING. STRAY MARKS AND SMUDGES COULD BE READ AS ANSWERS, SO ERASE CAREFULLY AND COMPLETELY. ANY IMPROPER GRIDDING MAY AFFECT YOUR GRADE.

1 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	26 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	51 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	27 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	52 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	28 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	53 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
4 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	29 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	54 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
5 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	30 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	55 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
6 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	31 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	56 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	32 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	57 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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18 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	43 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	68 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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20 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	45 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	70 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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22 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	47 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	72 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
23 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	48 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	73 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
24 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	49 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	74 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
25 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	50 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	75 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

DO NOT WRITE IN THIS AREA.

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. IF A QUESTION HAS ONLY FOUR ANSWER OPTIONS, DO NOT MARK OPTION E.

76 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   101 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   126 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
77 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   102 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   127 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
78 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   103 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   128 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
79 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   104 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   129 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
80 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   105 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   130 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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82 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   107 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   132 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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87 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   112 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   137 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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89 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   114 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   139 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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95 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   120 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   145 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
96 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   121 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   146 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
97 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   122 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   147 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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99 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   124 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   149 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
100 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   125 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   150 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
                                        151 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

ETS USE ONLY			
	R	W	FS
PT1			
PT2			
PT3			
PT4			
TOT			
EQ			
TA1			
TA2			

AREA 3 – COMPLETE THIS AREA ONLY ONCE.

1. YOUR MAILING ADDRESS

- YOUR GRADE REPORT WILL BE MAILED TO THIS ADDRESS IN JULY.
- USING THE ABBREVIATIONS GIVEN IN YOUR CANDIDATE PACK, FILL ADDRESS INTO BOXES PROVIDED. IF YOUR ADDRESS DOES NOT FIT, SEE ITEM 2 BELOW.
- INDICATE A SPACE IN YOUR ADDRESS BY LEAVING A BLANK BOX AND FILLING IN THE CORRESPONDING DIAMOND (◇) BELOW THE BOX.

Street

City

STATE

1 ○ AL	28 ○ NE		
2 ○ AK	29 ○ NV		
3 ○ AZ	30 ○ NH		
4 ○ AR	31 ○ NJ		
5 ○ CA	32 ○ NM		
6 ○ CO	33 ○ NY		
7 ○ CT	34 ○ NC		
8 ○ DE	35 ○ ND		
9 ○ DC	36 ○ OH		
10 ○ FL	37 ○ OK		
11 ○ GA	38 ○ OR		
12 ○ HI	39 ○ PA		
13 ○ ID	40 ○ RI		
14 ○ IL	41 ○ SC		
15 ○ IN	42 ○ SD		
16 ○ IA	43 ○ TN		
17 ○ KS	44 ○ TX		
18 ○ KY	45 ○ UT		
19 ○ LA	46 ○ VT		
20 ○ ME	47 ○ VA		
21 ○ MD	48 ○ WA		
22 ○ MA	49 ○ WV		
23 ○ MI	50 ○ WI		
24 ○ MN	51 ○ WY		
25 ○ MS	52 ○ Puerto Rico		
26 ○ MO	53 ○ Other		
27 ○ MT			

ZIP OR POSTAL CODE

1a. COUNTRY CODE

2. If the address gridded above is not complete enough for delivery of your grade report, please fill in this oval and print your complete address below. ⟶ ○

Address

City

State or Province

Zip or Postal Code

Country

3. TELEPHONE NUMBER

Area Code

4. SCHOOL YOU ATTEND

School Code

⟶ Make sure you have correctly entered your School Code and filled in the appropriate ovals.

School Name, City, and State

School Name

City

State

5. COLLEGE TO RECEIVE YOUR AP GRADES

College Code

Using the College Code list in the AP Candidate Pack, indicate the one college that has accepted you and that you plan to attend.

College Name and Address

College Name

City

State

CALCULUS AB

A CALCULATOR **CANNOT BE USED ON PART A OF SECTION I**. A GRAPHING CALCULATOR FROM THE APPROVED LIST **IS REQUIRED ON PART B OF SECTION I AND FOR SECTION II** OF THE EXAMINATION. CALCULATOR MEMORIES NEED NOT BE CLEARED. COMPUTERS, NONGRAPHING SCIENTIFIC CALCULATORS, CALCULATORS WITH QWERTY KEYBOARDS, AND ELECTRONIC WRITING PADS ARE NOT ALLOWED. CALCULATORS MAY NOT BE SHARED AND COMMUNICATION BETWEEN CALCULATORS IS PROHIBITED DURING THE EXAMINATION. ATTEMPTS TO REMOVE TEST MATERIALS FROM THE ROOM BY ANY METHOD WILL RESULT IN THE INVALIDATION OF TEST SCORES.

SECTION I

Time — 1 hour and 45 minutes

All questions are given equal weight.

Percent of total grade — 50

Part A: 55 minutes, 28 multiple-choice questions
A calculator is NOT allowed.

Part B: 50 minutes, 17 multiple-choice questions
A graphing calculator is required.

Parts A and B of Section I are printed in this examination booklet; Section II, which consists of longer problems, is printed in a separate booklet.

General Instructions

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

INDICATE YOUR ANSWERS TO QUESTIONS IN PART A ON PAGE 2 OF THE SEPARATE ANSWER SHEET. THE ANSWERS TO QUESTIONS IN PART B SHOULD BE INDICATED ON PAGE 3 OF THE ANSWER SHEET. No credit will be given for anything written in this examination booklet, but you may use the booklet for notes or scratchwork. After you have decided which of the suggested answers is best, COMPLETELY fill in the corresponding oval on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely.

Example: Sample Answer

What is the arithmetic mean of the numbers 1, 3, and 6 ?   Ⓐ Ⓑ Ⓒ ● Ⓔ

(A) 1

(B) $\frac{7}{3}$

(C) 3

(D) $\frac{10}{3}$

(E) $\frac{7}{2}$

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. In this section of the examination, as a correction for haphazard guessing, one-fourth of the number of questions you answer incorrectly will be subtracted from the number of questions you answer correctly. It is improbable, therefore, that mere guessing will improve your score significantly; it may even lower your score, and it does take time. If, however, you are not sure of the best answer but have some knowledge of the question and are able to eliminate one or more of the answer choices as wrong, your chance of answering correctly is improved, and it may be to your advantage to answer such a question.

Use your time effectively, working as rapidly as you can without losing accuracy. Do not spend too much time on questions that are too difficult. Go on to other questions and come back to the difficult ones later if you have time. It is not expected that everyone will be able to answer all the multiple-choice questions.

CALCULUS AB

SECTION I, Part A

Time — 55 minutes

Number of questions — 28

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

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

In this test: 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.

1. What is the x-coordinate of the point of inflection on the graph of $y = \frac{1}{3}x^3 + 5x^2 + 24$?
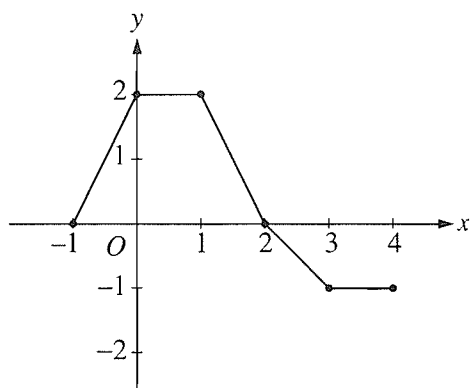
(A) 5   (B) 0   (C) $-\frac{10}{3}$ (D) -5 (E) -10

8

2. The graph of a piecewise-linear function f, for $-1 \le x \le 4$, is shown above. What is the value of
$\int_{-1}^{4} f(x)\, dx$?

(A) 1   (B) 2.5   (C) 4   (D) 5.5   (E) 8

3. $\int_{1}^{2} \dfrac{1}{x^2}\, dx =$

(A) $-\dfrac{1}{2}$ (B) $\dfrac{7}{24}$ (C) $\dfrac{1}{2}$ (D) 1   (E) $2 \ln 2$

GO ON TO THE NEXT PAGE

4. If f is continuous for $a \leq x \leq b$ and differentiable for $a < x < b$, which of the following could be false?

(A) $f'(c) = \dfrac{f(b) - f(a)}{b - a}$ for some c such that $a < c < b$.

(B) $f'(c) = 0$ for some c such that $a < c < b$.

(C) f has a minimum value on $a \leq x \leq b$.

(D) f has a maximum value on $a \leq x \leq b$.

(E) $\displaystyle\int_a^b f(x)\, dx$ exists.

5. $\displaystyle\int_0^x \sin t \, dt =$

(A) $\sin x$ (B) $-\cos x$ (C) $\cos x$ (D) $\cos x - 1$ (E) $1 - \cos x$

6. If $x^2 + xy = 10$, then when $x = 2$, $\dfrac{dy}{dx} =$

(A) $-\dfrac{7}{2}$
(B) -2
(C) $\dfrac{2}{7}$
(D) $\dfrac{3}{2}$
(E) $\dfrac{7}{2}$

7. $\displaystyle\int_{1}^{e} \left(\dfrac{x^2 - 1}{x}\right) dx =$

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

GO ON TO THE NEXT PAGE

8. Let f and g be differentiable functions with the following properties:

   (i) $g(x) > 0$ for all x

   (ii) $f(0) = 1$

If $h(x) = f(x)g(x)$ and $h'(x) = f(x)g'(x)$, then $f(x) =$
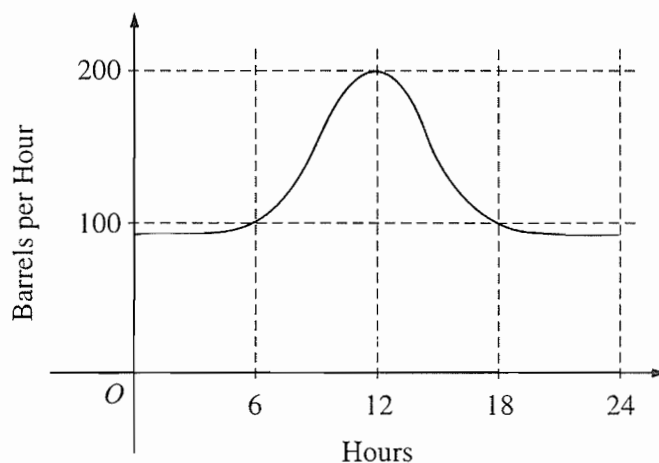
(A) $f'(x)$ (B) $g(x)$ (C) e^x (D) 0   (E) 1

9. The flow of oil, in barrels per hour, through a pipeline on July 9 is given by the graph shown above. Of the following, which best approximates the total number of barrels of oil that passed through the pipeline that day?

(A) 500   (B) 600   (C) 2,400   (D) 3,000   (E) 4,800

10. What is the instantaneous rate of change at $x = 2$ of the function f given by $f(x) = \dfrac{x^2 - 2}{x - 1}$?

(A) -2 (B) $\dfrac{1}{6}$ (C) $\dfrac{1}{2}$ (D) 2 (E) 6
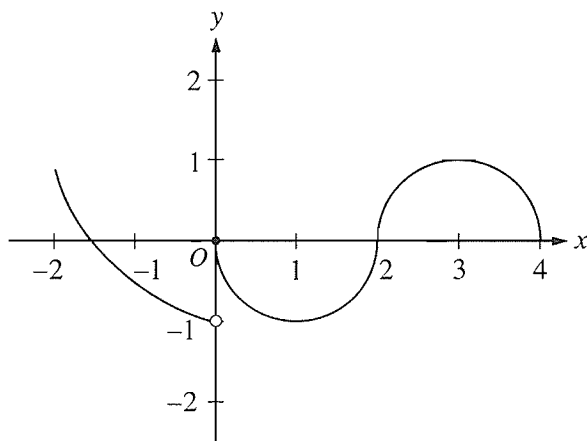
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11. If f is a linear function and $0 < a < b$, then $\displaystyle\int_{a}^{b} f''(x)\, dx =$

(A) 0 (B) 1 (C) $\dfrac{ab}{2}$ (D) $b - a$ (E) $\dfrac{b^2 - a^2}{2}$

GO ON TO THE NEXT PAGE

12. If $f(x) = \begin{cases} \ln x & \text{for } 0 < x \le 2 \\ x^2 \ln 2 & \text{for } 2 < x \le 4, \end{cases}$ then $\lim\limits_{x \to 2} f(x)$ is

(A) ln 2   (B) ln 8   (C) ln 16   (D) 4   (E) nonexistent

13. The graph of the function f shown in the figure above has a vertical tangent at the point $(2, 0)$ and horizontal tangents at the points $(1, -1)$ and $(3, 1)$. For what values of x, $-2 < x < 4$, is f not differentiable?

(A) 0 only   (B) 0 and 2 only   (C) 1 and 3 only   (D) 0, 1, and 3 only   (E) 0, 1, 2, and 3

GO ON TO THE NEXT PAGE

14. A particle moves along the x-axis so that its position at time t is given by $x(t) = t^2 - 6t + 5$. For what value of t is the velocity of the particle zero?
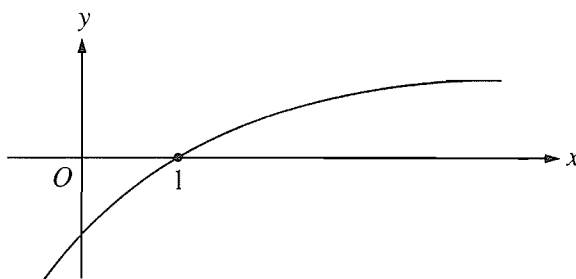
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

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15. If $F(x) = \displaystyle\int_0^x \sqrt{t^3 + 1} \, dt$, then $F'(2) =$

(A) -3 (B) -2 (C) 2 (D) 3 (E) 18

GO ON TO THE NEXT PAGE

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

(A) $-\cos(e^{-x})$

(B) $\cos(e^{-x}) + e^{-x}$

(C) $\cos(e^{-x}) - e^{-x}$

(D) $e^{-x}\cos(e^{-x})$

(E) $-e^{-x}\cos(e^{-x})$

17. The graph of a twice-differentiable function f is shown in the figure above. Which of the following is true?

(A) $f(1) < f'(1) < f''(1)$

(B) $f(1) < f''(1) < f'(1)$

(C) $f'(1) < f(1) < f''(1)$

(D) $f''(1) < f(1) < f'(1)$

(E) $f''(1) < f'(1) < f(1)$

18. An equation of the line tangent to the graph of $y = x + \cos x$ at the point $(0, 1)$ is

    (A) $y = 2x + 1$ (B) $y = x + 1$ (C) $y = x$ (D) $y = x - 1$ (E) $y = 0$

---

19. If $f''(x) = x(x + 1)(x - 2)^2$, then the graph of f has inflection points when $x =$

    (A) -1 only   (B) 2 only   (C) -1 and 0 only   (D) -1 and 2 only   (E) -1, 0, and 2 only

GO ON TO THE NEXT PAGE

20. What are all values of k for which $\displaystyle\int_{-3}^{k} x^2\, dx = 0$?

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

---

21. If $\dfrac{dy}{dt} = ky$ and k is a nonzero constant, then y could be

(A) $2e^{kty}$ (B) $2e^{kt}$ (C) $e^{kt} + 3$ (D) $kty + 5$ (E) $\dfrac{1}{2}ky^2 + \dfrac{1}{2}$

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22. The function f is given by $f(x) = x^4 + x^2 - 2$. On which of the following intervals is f increasing?
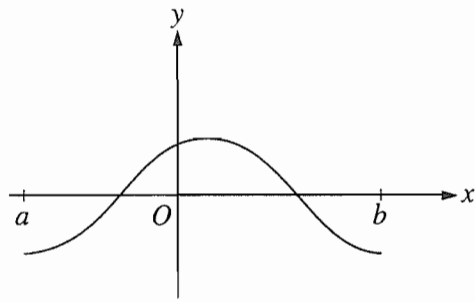
(A) $\left(-\dfrac{1}{\sqrt{2}}, \ \infty\right)$

(B) $\left(-\dfrac{1}{\sqrt{2}}, \ \dfrac{1}{\sqrt{2}}\right)$

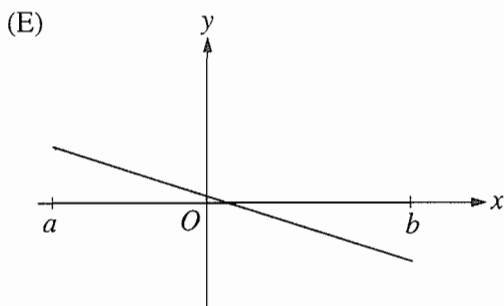(C) $(0, \ \infty)$

(D) $(-\infty, \ 0)$

(E) $\left(-\infty, \ -\dfrac{1}{\sqrt{2}}\right)$

19

23. The graph of f is shown in the figure above. Which of the following could be the graph of the derivative of f ?

(A)

(B)

(C)

(D)
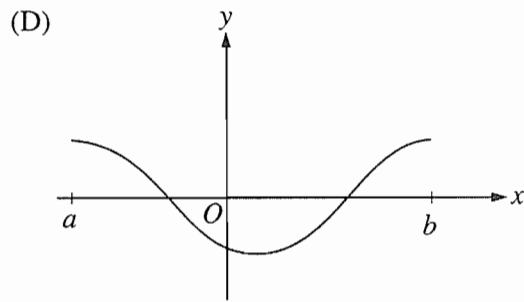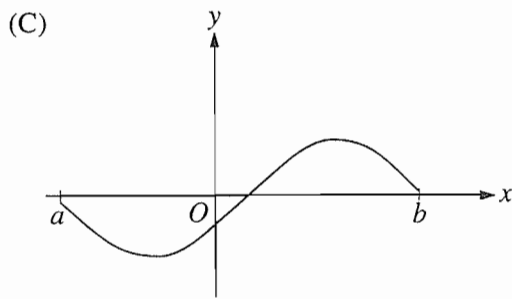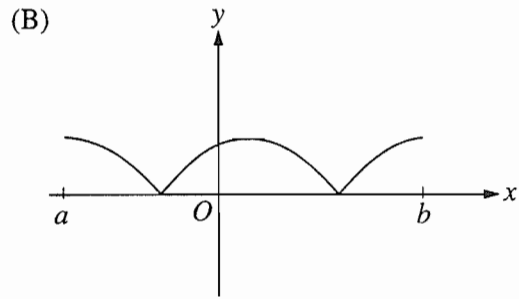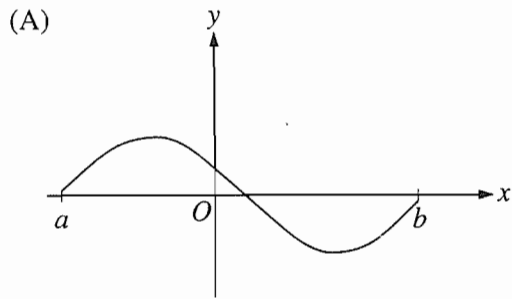
(E)

24. The maximum acceleration attained on the interval $0 \leq t \leq 3$ by the particle whose velocity is given by $v(t) = t^3 - 3t^2 + 12t + 4$ is

(A) 9   (B) 12   (C) 14   (D) 21   (E) 40

25. What is the area of the region between the graphs of $y = x^2$ and $y = -x$ from $x = 0$ to $x = 2$?

(A) $\dfrac{2}{3}$ (B) $\dfrac{8}{3}$ (C) 4   (D) $\dfrac{14}{3}$ (E) $\dfrac{16}{3}$

GO ON TO THE NEXT PAGE

x	0	1	2
$f(x)$	1	k	2

26. The function f is continuous on the closed interval $[0, 2]$ and has values that are given in the table above. The equation $f(x) = \frac{1}{2}$ must have at least two solutions in the interval $[0, 2]$ if $k =$

(A) 0   (B) $\frac{1}{2}$ (C) 1   (D) 2   (E) 3

27. What is the average value of $y = x^2\sqrt{x^3 + 1}$ on the interval $[0, 2]$?

(A) $\frac{26}{9}$ (B) $\frac{52}{9}$ (C) $\frac{26}{3}$ (D) $\frac{52}{3}$ (E) 24

28. If $f(x) = \tan(2x)$, then $f'\left(\dfrac{\pi}{6}\right) =$

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

END OF PART A OF SECTION I

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

CALCULUS AB

SECTION I, Part B

Time — 50 minutes

Number of questions — 17

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

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

BE SURE YOU ARE USING PAGE 3 OF THE ANSWER SHEET TO RECORD YOUR ANSWERS TO QUESTIONS NUMBERED 76-92.

YOU MAY NOT RETURN TO PAGE 2 OF THE ANSWER SHEET.

In this test:

(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.

GO ON TO THE NEXT PAGE

24
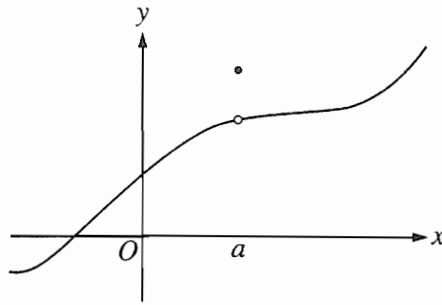
76. The graph of a function f is shown above. Which of the following statements about f is false?

    (A) f is continuous at $x = a$.

    (B) f has a relative maximum at $x = a$.

    (C) $x = a$ is in the domain of f.

    (D) $\lim\limits_{x \to a^+} f(x)$ is equal to $\lim\limits_{x \to a^-} f(x)$.

    (E) $\lim\limits_{x \to a} f(x)$ exists.

77. Let f be the function given by $f(x) = 3e^{2x}$ and let g be the function given by $g(x) = 6x^3$. At what value of x do the graphs of f and g have parallel tangent lines?

(A) -0.701
(B) -0.567
(C) -0.391
(D) -0.302
(E) -0.258

78. The radius of a circle is decreasing at a constant rate of 0.1 centimeter per second. In terms of the circumference C, what is the rate of change of the area of the circle, in square centimeters per second?

(A) $-(0.2)\pi C$

(B) $-(0.1)C$

(C) $-\dfrac{(0.1)C}{2\pi}$

(D) $(0.1)^2 C$

(E) $(0.1)^2 \pi C$
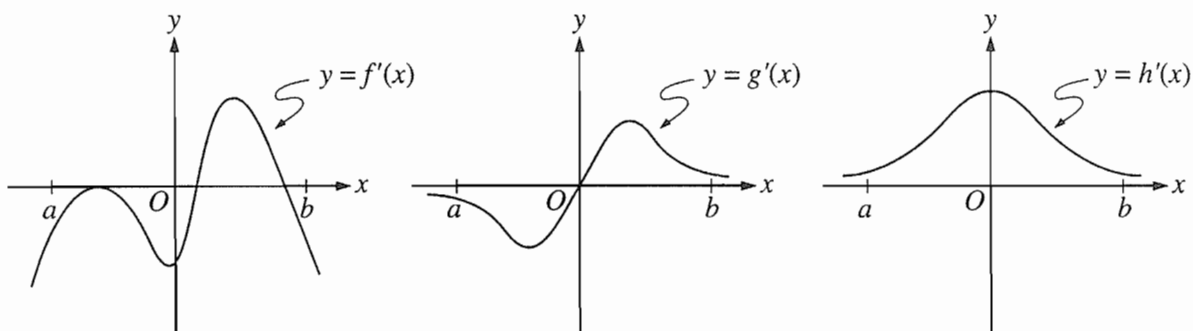
79. The graphs of the derivatives of the functions f, g, and h are shown above. Which of the functions f, g, or h have a relative maximum on the open interval $a < x < b$?

(A) f only
(B) g only
(C) h only
(D) f and g only
(E) f, g, and h

80. The first derivative of the function f is given by $f'(x) = \dfrac{\cos^2 x}{x} - \dfrac{1}{5}$. How many critical values does f have on the open interval $(0, 10)$?

(A) One
(B) Three
(C) Four
(D) Five
(E) Seven

GO ON TO THE NEXT PAGE

27

81. Let f be the function given by $f(x) = |x|$. Which of the following statements about f are true?

    I. f is continuous at $x = 0$.
    II. f is differentiable at $x = 0$.
    III. f has an absolute minimum at $x = 0$.

(A) I only   (B) II only   (C) III only   (D) I and III only   (E) II and III only

---

82. If f is a continuous function and if $F'(x) = f(x)$ for all real numbers x, then $\int_{1}^{3} f(2x)\,dx =$

(A) $2F(3) - 2F(1)$

(B) $\frac{1}{2}F(3) - \frac{1}{2}F(1)$

(C) $2F(6) - 2F(2)$

(D) $F(6) - F(2)$

(E) $\frac{1}{2}F(6) - \frac{1}{2}F(2)$

83. If $a \neq 0$, then $\lim\limits_{x \to a} \dfrac{x^2 - a^2}{x^4 - a^4}$ is

(A) $\dfrac{1}{a^2}$ (B) $\dfrac{1}{2a^2}$ (C) $\dfrac{1}{6a^2}$ (D) 0   (E) nonexistent

84. Population y grows according to the equation $\dfrac{dy}{dt} = ky$, where k is a constant and t is measured in years. If the population doubles every 10 years, then the value of k is

(A) 0.069   (B) 0.200   (C) 0.301   (D) 3.322   (E) 5.000

GO ON TO THE NEXT PAGE

x	2	5	7	8
$f(x)$	10	30	40	20

85. The function f is continuous on the closed interval [2, 8] and has values that are given in the table above. Using the subintervals [2, 5], [5, 7], and [7, 8], what is the trapezoidal approximation of

$$\int_{2}^{8} f(x)\,dx\ ?$$

(A) 110   (B) 130   (C) 160   (D) 190   (E) 210
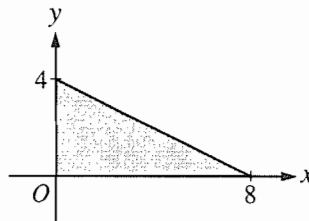
86. The base of a solid is a region in the first quadrant bounded by the x-axis, the y-axis, and the line $x + 2y = 8,$ as shown in the figure above. If cross sections of the solid perpendicular to the x-axis are semicircles, what is the volume of the solid?

(A) 12.566   (B) 14.661   (C) 16.755   (D) 67.021   (E) 134.041

87. Which of the following is an equation of the line tangent to the graph of $f(x) = x^4 + 2x^2$ at the point where $f'(x) = 1$?

(A) $y = 8x - 5$
(B) $y = x + 7$
(C) $y = x + 0.763$
(D) $y = x - 0.122$
(E) $y = x - 2.146$

---

88. Let $F(x)$ be an antiderivative of $\dfrac{(\ln x)^3}{x}$. If $F(1) = 0$, then $F(9) =$

(A) 0.048　　　(B) 0.144　　　(C) 5.827　　　(D) 23.308　　　(E) 1,640.250

31

89. If g is a differentiable function such that $g(x) < 0$ for all real numbers x and if $f'(x) = (x^2 - 4)g(x)$, which of the following is true?

(A) f has a relative maximum at $x = -2$ and a relative minimum at $x = 2$.
(B) f has a relative minimum at $x = -2$ and a relative maximum at $x = 2$.
(C) f has relative minima at $x = -2$ and at $x = 2$.
(D) f has relative maxima at $x = -2$ and at $x = 2$.
(E) It cannot be determined if f has any relative extrema.

90. If the base b of a triangle is increasing at a rate of 3 inches per minute while its height h is decreasing at a rate of 3 inches per minute, which of the following must be true about the area A of the triangle?

(A) A is always increasing.
(B) A is always decreasing.
(C) A is decreasing only when $b < h$.
(D) A is decreasing only when $b > h$.
(E) A remains constant.

91. Let f be a function that is differentiable on the open interval $(1, 10)$. If $f(2) = -5$, $f(5) = 5$, and $f(9) = -5$, which of the following must be true?

    I. f has at least 2 zeros.
    II. The graph of f has at least one horizontal tangent.
    III. For some c, $2 < c < 5$, $f(c) = 3$.

  (A) None
  (B) I only
  (C) I and II only
  (D) I and III only
  (E) I, II and III

---

92. If $0 \le k < \dfrac{\pi}{2}$ and the area under the curve $y = \cos x$ from $x = k$ to $x = \dfrac{\pi}{2}$ is 0.1, then $k =$

  (A) 1.471   (B) 1.414   (C) 1.277   (D) 1.120   (E) 0.436

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.

MAKE SURE YOU HAVE PLACED YOUR AP NUMBER LABEL ON YOUR
ANSWER SHEET AND HAVE WRITTEN AND GRIDDED YOUR AP NUMBER
IN THE APPROPRIATE SECTION OF YOUR ANSWER SHEET.

AFTER TIME HAS BEEN CALLED, ANSWER QUESTIONS 93-96.

93. Which graphing calculator did you use during the examination?

    (A) Casio 6300, Casio 7000, Casio 7300, Casio 7400, or Casio 7700
    (B) Texas Instruments TI-80 or TI-81
    (C) Casio 9700, Casio 9800, Casio 9850, Sharp 9200, Sharp 9300, Texas Instruments TI-82, Texas Instruments TI-83, Texas Instruments TI-85, or Texas Instruments TI-86
    (D) Hewlett-Packard HP-48 series or HP-38G
    (E) Some other calculator

94. During your Calculus AB course, which of the following best describes your calculator use?

    (A) I used my own graphing calculator.
    (B) I used a graphing calculator furnished by my school, both in class and at home.
    (C) I used a graphing calculator furnished by my school only in class.
    (D) I used a graphing calculator furnished by my school mostly in class, but occasionally at home.
    (E) I did not use a graphing calculator.

95. During your Calculus AB course, which of the following describes approximately how often a graphing calculator was used by you or your teacher in classroom learning activities?

    (A) Almost every class
    (B) About three-quarters of the classes
    (C) About one-half of the classes
    (D) About one-quarter of the classes
    (E) Seldom or never

96. During your Calculus AB course, which of the following describes approximately how often you were allowed to use a graphing calculator on tests?

    (A) Almost all of the time
    (B) About three-quarters of the time
    (C) About one-half of the time
    (D) About one-quarter of the time
    (E) Seldom or never

CALCULUS AB
SECTION II
Time — 1 hour and 30 minutes
Number of problems — 6
Percent of total grade — 50

GENERAL INSTRUCTIONS

You may wish to look over the problems before starting to work on them, since it is not expected that everyone will be able to complete all parts of all problems. All problems are given equal weight, but the parts of a particular problem are not necessarily given equal weight. The problems are printed in the booklet and in the green insert; it may be easier for you to first look over all problems in the insert. When you are told to begin, open your booklet, carefully tear out the green insert, and start to work.

A GRAPHING CALCULATOR IS REQUIRED FOR SOME PROBLEMS OR PARTS OF PROBLEMS ON THIS SECTION OF THE EXAMINATION.

- You should write all work for each part of each problem in the space provided for that part in the booklet. Be sure to write clearly and legibly. If you make an error, you may save time by crossing it out rather than trying to erase it. Erased or crossed-out work will not be graded.

- Show all your work. You will be graded on the correctness and completeness of your methods as well as the accuracy of your final answers. Correct answers without supporting work may not receive credit.

- Justifications require that you give mathematical (noncalculator) reasons and that you clearly identify functions, graphs, tables, or other objects you use.

- 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 problem, 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.

- 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(X^2, X, 1, 5).

- Unless otherwise specified, answers (numeric or algebraic) need not be simplified. If your answer is given as a decimal approximation. it should be correct 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.

CALCULUS AB

SECTION II

Time — 1 hour and 30 minutes

Number of problems — 6

Percent of total grade — 50

A GRAPHING CALCULATOR IS REQUIRED FOR SOME PROBLEMS OR
PARTS OF PROBLEMS ON THIS SECTION OF THE EXAMINATION.

REMEMBER TO SHOW YOUR SETUPS AS DESCRIBED IN THE GENERAL INSTRUCTIONS.

General instructions for this section are printed on the back cover of this booklet.

1. Let R be the region bounded by the x-axis, the graph of $y = \sqrt{x}$, and the line $x = 4$.

(a) Find the area of the region R.

___

(b) Find the value of h such that the vertical line $x = h$ divides the region R into two regions of equal area.

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

(d) The vertical line $x = k$ divides the region R into two regions such that when these two regions are revolved about the x-axis, they generate solids with equal volumes. Find the value of k.

2. Let f be the function given by $f(x) = 2xe^{2x}$.

(a) Find $\lim\limits_{x \to -\infty} f(x)$ and $\lim\limits_{x \to \infty} f(x)$.

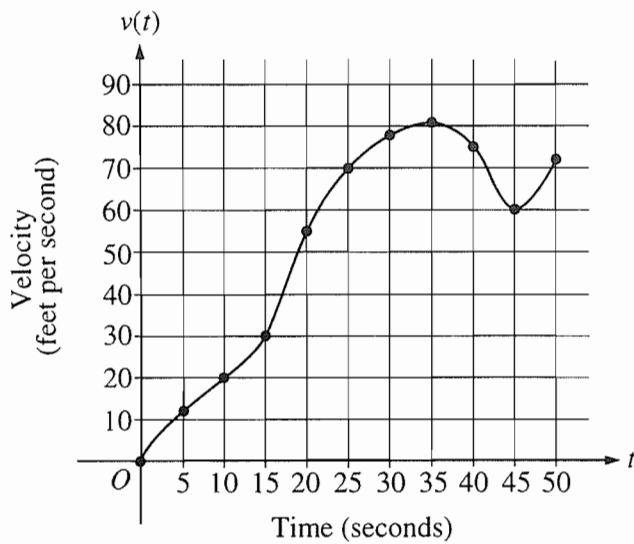(b) Find the absolute minimum value of f. Justify that your answer is an absolute minimum.

(c) What is the range of f?

(d) Consider the family of functions defined by $y = bxe^{bx}$, where b is a nonzero constant. Show that the absolute minimum value of bxe^{bx} is the same for all nonzero values of b.

t (seconds)	$v(t)$ (feet per second)
0	0
5	12
10	20
15	30
20	55
25	70
30	78
35	81
40	75
45	60
50	72

3. The graph of the velocity $v(t)$, in ft/sec, of a car traveling on a straight road, for $0 \le t \le 50$, is shown above. A table of values for $v(t)$, at 5 second intervals of time t, is shown to the right of the graph.

(a) During what intervals of time is the acceleration of the car positive? Give a reason for your answer.

(b) Find the average acceleration of the car, in ft/sec², over the interval $0 \le t \le 50$.

(c) Find one approximation for the acceleration of the car, in ft/sec^2, at $t = 40$. Show the computations you used to arrive at your answer.

(d) Approximate $\displaystyle\int_0^{50} v(t)\, dt$ with a Riemann sum, using the midpoints of five subintervals of equal length. Using correct units, explain the meaning of this integral.

4. Let f be a function with $f(1) = 4$ such that for all points (x, y) on the graph of f the slope is given by $\dfrac{3x^2 + 1}{2y}$.

(a) Find the slope of the graph of f at the point where $x = 1$.

(b) Write an equation for the line tangent to the graph of f at $x = 1$ and use it to approximate $f(1.2)$.

(c) Find $f(x)$ by solving the separable differential equation $\dfrac{dy}{dx} = \dfrac{3x^2 + 1}{2y}$ with the initial condition $f(1) = 4$.
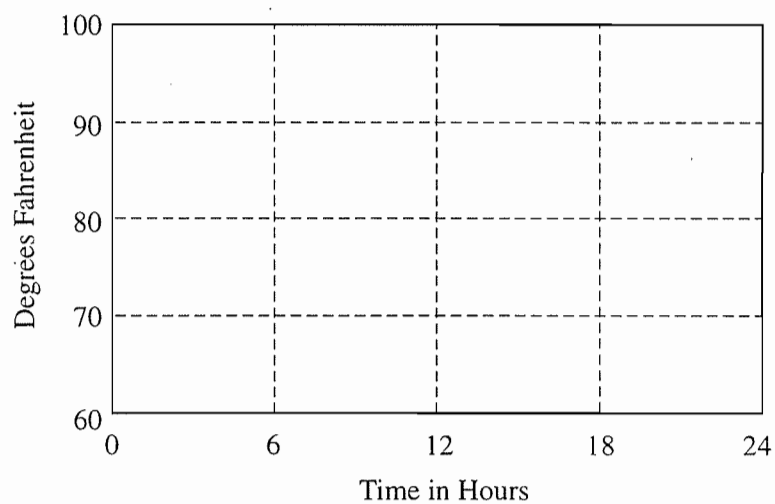
(d) Use your solution from part (c) to find $f(1.2)$.

5. The temperature outside a house during a 24-hour period is given by

$$F(t) = 80 - 10 \cos\left(\frac{\pi t}{12}\right), \ 0 \leq t \leq 24,$$

where $F(t)$ is measured in degrees Fahrenheit and t is measured in hours.

(a) Sketch the graph of F on the grid below.

(b) Find the average temperature, to the nearest degree Fahrenheit, between $t = 6$ and $t = 14$.

(c) An air conditioner cooled the house whenever the outside temperature was at or above 78 degrees Fahrenheit. For what values of t was the air conditioner cooling the house?

(d) The cost of cooling the house accumulates at the rate of $0.05 per hour for each degree the outside temperature exceeds 78 degrees Fahrenheit. What was the total cost, to the nearest cent, to cool the house for this 24-hour period?

6. Consider the curve defined by $2y^3 + 6x^2y - 12x^2 + 6y = 1$.

(a) Show that $\dfrac{dy}{dx} = \dfrac{4x - 2xy}{x^2 + y^2 + 1}$.

_____

(b) Write an equation of each horizontal tangent line to the curve.

46

(c) The line through the origin with slope -1 is tangent to the curve at point P. Find the x- and y-coordinates of point P.

END OF EXAMINATION