



## AP<sup>®</sup> Calculus AB 2003 Sample Student Responses Form B

**The materials included in these files are intended for use by AP teachers for course and exam preparation; permission for any other use must be sought from the Advanced Placement Program<sup>®</sup>. Teachers may reproduce them, in whole or in part, in limited quantities for noncommercial, face-to-face teaching purposes. This permission does not apply to any third-party copyrights contained herein. This material may not be mass distributed, electronically or otherwise. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here.**

These materials were produced by Educational Testing Service<sup>®</sup> (ETS<sup>®</sup>), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association whose mission is to prepare, inspire, and connect students to college and opportunity. Founded in 1900, the association is composed of more than 4,300 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges through major programs and services in college admissions, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT<sup>®</sup>, the PSAT/NMSQT<sup>®</sup>, and the Advanced Placement Program<sup>®</sup> (AP<sup>®</sup>). The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

For further information, visit [www.collegeboard.com](http://www.collegeboard.com)

Copyright © 2003 College Entrance Examination Board. All rights reserved. College Board, Advanced Placement Program, AP, AP Vertical Teams, APCD, Pacesetter, Pre-AP, SAT, Student Search Service, and the acorn logo are registered trademarks of the College Entrance Examination Board. AP Central is a trademark owned by the College Entrance Examination Board. PSAT/NMSQT is a registered trademark jointly owned by the College Entrance Examination Board and the National Merit Scholarship Corporation. Educational Testing Service and ETS are registered trademarks of Educational Testing Service. Other products and services may be trademarks of their respective owners.

For the College Board's online home for AP professionals, visit AP Central at [apcentral.collegeboard.com](http://apcentral.collegeboard.com).

**NO CALCULATOR ALLOWED**

**CALCULUS AB  
SECTION II, Part B**

**Time—45 minutes**

**Number of problems—3**

**No calculator is allowed for these problems.**

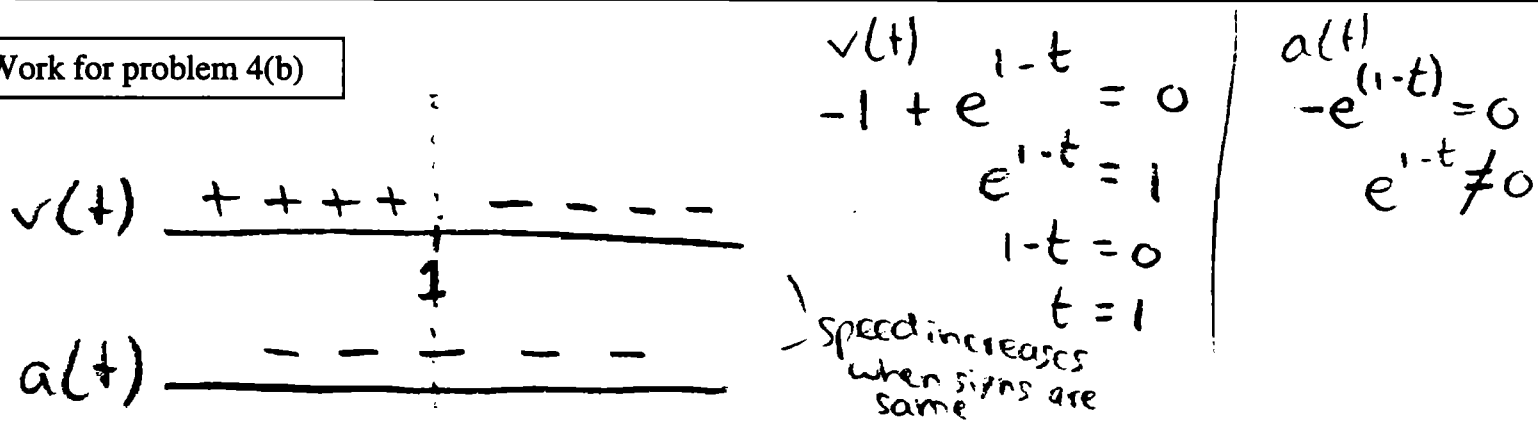
Work for problem 4(a)

$$v(t) = -1 + e^{(1-t)}$$

$$a(t) = v'(t) = -1(e^{(1-t)}) = -e^{1-t}$$

$$a(3) = -e^{1-3} = \boxed{-e^{-2}} = \frac{-1}{e^2}$$

Work for problem 4(b)



speed is increasing on  $(1, \infty)$   
 $t=3$  is within the interval  
 and thus speed is increasing

Continue problem 4 on page 11.

NO CALCULATOR ALLOWED

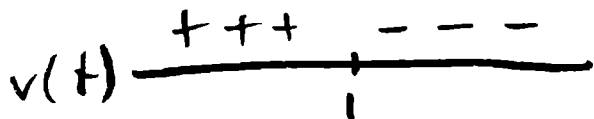
Work for problem 4(c)

$$v(t) = 0 = -1 + e^{1-t}$$

$$e^{1-t} = 1$$

$$1-t = 0$$

$$t = 1$$



the particle changes direction  
at  $t=1$

Work for problem 4(d)

$$d(t) = \int_0^1 (-1 + e^{1-t}) dt + \int_1^3 (-1 + e^{1-t}) dt =$$

$$-t \Big|_0^1 + -e^{1-t} \Big|_0^1 + t \Big|_1^3 + e^{1-t} \Big|_1^3 =$$

$$(-1 - 0) + (-1 + e) + (3 - 1) + (e^{-2} - 1) =$$

$$-1 - 1 + e + 2 + e^{-2} - 1 = \boxed{e + e^{-2} - 1}$$

GO ON TO THE NEXT PAGE.

4 4

4 4

4 4

4 4

4 4

C,

NO CALCULATOR ALLOWED

CALCULUS AB

SECTION II, Part B

Time—45 minutes

Number of problems—3

No calculator is allowed for these problems.

Work for problem 4(a)

$$\begin{aligned}
 v(t) &= -1 + e^{1-t} \\
 &= e^{1-t} - 1 \\
 v'(t) &= a(t) = e^{1-t}(-1) \\
 &= -e^{1-t}
 \end{aligned}$$

$v(t)$  = velocity  
 $a(t)$  = accel.

at  $t=3$ , then, accel. is  $-e^{1-3} = -e^{-2} = -\frac{1}{e^2}$

Work for problem 4(b)

at  $t=3$  acceleration is negative and velocity is  $-1 + e^{-2} = \frac{1}{e^2} - 1$  which is clearly negative (since  $\frac{1}{e^2} < 1$ ). Thus since acceleration is negative velocity is decreasing (becoming more negative). But speed is  $|\text{velocity}|$  (abs. value of velocity) and thus since velocity becomes more negative speed increases.

Continue problem 4 on page 11.

## NO CALCULATOR ALLOWED

Work for problem 4(c)

the particle is going in one direction when  $v(t)$  is positive, and another when  $v(t)$  is neg. so it changes direction at the zeroes of  $v(t)$ .

$$0 = -1 + e^{1-t}$$

$$e^{1-t} = 1$$

$$\ln(e^{1-t}) = \ln 1$$

$$1-t = 0$$

$t=1$  is a zero.

Testing points on either side  
( $t=0$  and  $t=2$ ) leads to

$$v(0) = -1 + e^1$$

$$= e - 1$$

$$= \text{pos because } e > 1$$

$$v(2) = -1 + e^{-1}$$

$$= \frac{1}{e} - 1$$

$$= \text{negative}$$

$$\text{since } \frac{1}{e} < 1$$

thus it changes direction at  $t=1$

Work for problem 4(d)

Total distance traveled =  $\int_0^3 v(t) dt$   
over  $0 \leq t \leq 3$

Let  $1-t = u$   
 $du = -1$

$$= \int_0^3 e^{1-t} dt - \int_0^3 1 dt$$

$$= -\int_0^3 e^u du - \int_0^3 1 dt$$

$$= [-e^{1-t}]_0^3 - [t]_0^3$$

$$(-e^{-2} + e^1) - (3-0)$$

$$e - \frac{1}{e^2} - 3 = \text{total dist traveled}$$

GO ON TO THE NEXT PAGE.