

2011 AP<sup>®</sup> CALCULUS AB FREE-RESPONSE QUESTIONS

CALCULUS AB  
SECTION II, Part A

Time—30 minutes

Number of problems—2

A graphing calculator is required for these problems.

1. For  $0 \leq t \leq 6$ , a particle is moving along the  $x$ -axis. The particle's position,  $x(t)$ , is not explicitly given. The velocity of the particle is given by  $v(t) = 2\sin(e^{t/4}) + 1$ . The acceleration of the particle is given by  $a(t) = \frac{1}{2}e^{t/4} \cos(e^{t/4})$  and  $x(0) = 2$ .
- (a) Is the speed of the particle increasing or decreasing at time  $t = 5.5$ ? Give a reason for your answer.
  - (b) Find the average velocity of the particle for the time period  $0 \leq t \leq 6$ .
  - (c) Find the total distance traveled by the particle from time  $t = 0$  to  $t = 6$ .
  - (d) For  $0 \leq t \leq 6$ , the particle changes direction exactly once. Find the position of the particle at that time.

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WRITE ALL WORK IN THE EXAM BOOKLET.

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6. For  $0 \leq t \leq 12$ , a particle moves along the  $x$ -axis. The velocity of the particle at time  $t$  is given by  $v(t) = \cos\left(\frac{\pi}{6}t\right)$ . The particle is at position  $x = -2$  at time  $t = 0$ .
- (a) For  $0 \leq t \leq 12$ , when is the particle moving to the left?
  - (b) Write, but do not evaluate, an integral expression that gives the total distance traveled by the particle from time  $t = 0$  to time  $t = 6$ .
  - (c) Find the acceleration of the particle at time  $t$ . Is the speed of the particle increasing, decreasing, or neither at time  $t = 4$ ? Explain your reasoning.
  - (d) Find the position of the particle at time  $t = 4$ .
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**STOP**

**END OF EXAM**

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2. A particle moves along a straight line. For  $0 \leq t \leq 5$ , the velocity of the particle is given by  $v(t) = -2 + (t^2 + 3t)^{6/5} - t^3$ , and the position of the particle is given by  $s(t)$ . It is known that  $s(0) = 10$ .
- (a) Find all values of  $t$  in the interval  $2 \leq t \leq 4$  for which the speed of the particle is 2.
  - (b) Write an expression involving an integral that gives the position  $s(t)$ . Use this expression to find the position of the particle at time  $t = 5$ .
  - (c) Find all times  $t$  in the interval  $0 \leq t \leq 5$  at which the particle changes direction. Justify your answer.
  - (d) Is the speed of the particle increasing or decreasing at time  $t = 4$ ? Give a reason for your answer.
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**END OF PART A OF SECTION II**

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$t$ (minutes)	0	2	5	8	12
$v_A(t)$ (meters/minute)	0	100	40	-120	-150

4. Train  $A$  runs back and forth on an east-west section of railroad track. Train  $A$ 's velocity, measured in meters per minute, is given by a differentiable function  $v_A(t)$ , where time  $t$  is measured in minutes. Selected values for  $v_A(t)$  are given in the table above.
- (a) Find the average acceleration of train  $A$  over the interval  $2 \leq t \leq 8$ .
- (b) Do the data in the table support the conclusion that train  $A$ 's velocity is  $-100$  meters per minute at some time  $t$  with  $5 < t < 8$ ? Give a reason for your answer.
- (c) At time  $t = 2$ , train  $A$ 's position is 300 meters east of the Origin Station, and the train is moving to the east. Write an expression involving an integral that gives the position of train  $A$ , in meters from the Origin Station, at time  $t = 12$ . Use a trapezoidal sum with three subintervals indicated by the table to approximate the position of the train at time  $t = 12$ .
- (d) A second train, train  $B$ , travels north from the Origin Station. At time  $t$  the velocity of train  $B$  is given by  $v_B(t) = -5t^2 + 60t + 25$ , and at time  $t = 2$  the train is 400 meters north of the station. Find the rate, in meters per minute, at which the distance between train  $A$  and train  $B$  is changing at time  $t = 2$ .
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No calculator is allowed for these problems.

$t$ (minutes)	0	12	20	24	40
$v(t)$ (meters per minute)	0	200	240	-220	150

3. Johanna jogs along a straight path. For  $0 \leq t \leq 40$ , Johanna's velocity is given by a differentiable function  $v$ . Selected values of  $v(t)$ , where  $t$  is measured in minutes and  $v(t)$  is measured in meters per minute, are given in the table above.

(a) Use the data in the table to estimate the value of  $v'(16)$ .

(b) Using correct units, explain the meaning of the definite integral  $\int_0^{40} |v(t)| dt$  in the context of the problem.

Approximate the value of  $\int_0^{40} |v(t)| dt$  using a right Riemann sum with the four subintervals indicated in the table.

(c) Bob is riding his bicycle along the same path. For  $0 \leq t \leq 10$ , Bob's velocity is modeled by

$$B(t) = t^3 - 6t^2 + 300, \text{ where } t \text{ is measured in minutes and } B(t) \text{ is measured in meters per minute.}$$

Find Bob's acceleration at time  $t = 5$ .

(d) Based on the model  $B$  from part (c), find Bob's average velocity during the interval  $0 \leq t \leq 10$ .

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